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EDITED BY

HENRY HEAD M.D. F.R.S.

WITH THE HELP OF

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BYROM BRAMWELL, M.D.
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ON THE GENESIS AND PHYSIOLOGICAL SIGNIFICANCE OF SPASTICITY AND OTHER DISORDERS OF MOTOR INNERVATION: WITH A CONSIDERATION OF THE FUNCTIONAL RELATIONSHIPS OF THE PYRAMIDAL SYSTEM.

BY F. M. R. WALSHE, M.D., TEMPORARY MAJOR R.A.M.C.

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I.—INTRODUCTION.

IN a previous paper [25] certain of the reflex phenomena seen in the lower limbs in spastic paralysis were described, and their physiological significance discussed. For the first time a serious attempt was made to identify in man those principles underlying the physiological activity of the nervous system which the researches of Sherrington have revealed in the lower animals.

In particular, certain reflex movements were described, and in the investigation of the conditioning, form, and significance of these as purposive reactions, certain general principles in the functional activity of the spinal cord in man were elucidated, and it was concluded that "analysis of the phenomena of spastic paralysis of the lower limbs in man demonstrates the close analogy existing between the physiological principles of motor innervation in animals and in man."

The allied phenomenon of spasticity, or hypertonus, associated with pyramidal lesions, also necessarily came under review, since it possesses to a large extent the same anatomical and physiological basis as the reflex movements in question—being, indeed, it was suggested, the characteristic expression of the activity of another reflex system in the central nervous system. Yet many aspects of the problem remained untouched, and a subsequent study of these was planned. During the intervening period, however, circumstances have not allowed of its completion. In the meantime the fruitful researches of Head and of Riddoch [9], [18], in the same field, have established the validity of the principles then laid down, and have also added considerably to our knowledge of the functional capabilities of the isolated spinal cord in man.

The subject may be resumed, therefore, in the hope of still farther elucidating some of the many vexed problems in the motor innervation of the skeletal musculature that yet remain for solution.

It is widely recognized, in considering the functions of the pyramidal system, and in studying the phenomena that follow its interruption, that we must take into account those other efferent paths that research, during the past two decades especially, has shown to play so essential a rôle in motor innervation. The problem therefore resolves itself into but a single aspect of the larger question of the functional relationships of the pyramidal system with the other components of the efferent system.

It is our imperfect knowledge of these, both anatomically and physiologically, that renders the problem so difficult and obscure.

Our methods of clinico-pathological and of physiological investigation into the functions of a motor path are based upon the study of excitation and destruction phenomena, and consideration will show that these methods do not provide us with simple positive and negative pictures from which we may deduce directly the functions of a single system.

To the performance of a voluntary, purposive and co-ordinated movement go many factors. In stimulation experiments on the "motor cortex" we see a complex motor mechanism at work under the influence of an abnormally induced, crude form of hyper-activity of the predominant partner in this mechanism. Conversely, after destructive lesions, we observe it at work liberated from the control of this predominant partner and deprived of its actual co-operation.

In other words, we are studying a mutilated residual innervation, itself probably composed of several factors, and capable of resolution into simpler components.

Broadbent [2] has lucidly stated the position in terms of the Jacksonian principle: "The functions of a centre in which a lesion has occurred are suspended, and corresponding symptoms which may be called negative are observed. These, however, are not the only symptoms; other symptoms usually more obtrusive, and often infinitely more important, are produced by the activities of other centres, either (*a*) unbalanced in consequence of the absence of normally opposing activities; or (*b*) liberated from the control of higher level centres; or (*c*) intensified by attempts to compensate for the missing functions." (Super-positive activities, e.g., that of the opposite internal rectus on external rectus paralysis).

It is out of this reaction of the entire nervous system to injury of one of its component parts that we have to form our conception of the normal functions of the system which has fallen out.

As v. Monakow points out, there are three aspects from which the problem of cerebral localization may be approached. The purely anatomical localization, i.e., of tracts and cell stations, the localization of symptoms and symptom-complexes by clinical and pathological investigation of disease, and the localization of function, which is the most difficult of the three, and he concludes: "Nichts hat die Diskussion über den Lokalisation im Grosshirn so sehr verwirrt und in unfruchtbare Bahnen gelenkt, als die Nichtbeachtung der Verschiedenheit in der Fragestellung, die jede dieser Lokalisationsweisen zur Grundlage hat" [17]. Herein undoubtedly lies the peculiar danger in the acceptance of hypotheses based entirely on clinico-pathological data, and uncontrolled by physiological observations.

It will be readily admitted, when we compare the coarse undiscriminating lesions which provide the bulk of clinical and pathological material with the clean-cut selective lesions produced by the experimental physiologist, that the latter has many advantages in approaching the problem of localization of cerebral function. An approximate

localization of symptoms is often all that the clinician can hope to achieve.

Recent observations, both clinical and experimental, may appear at first sight to have dethroned the pyramidal system from its position of pre-eminence among central efferent paths. Among neurologists the grave disorders of motion seen in such diseases as paralysis agitans, the midbrain lesions described by Gordon Holmes [10], and the corpus striatum syndromes of C. Vogt and of S. A. K. Wilson [27], associated as they are with an intact cortico-spinal system, have thrown into great prominence the part played by "extra-pyramidal motor paths." To the rubro-spinal tract, in particular, has been ascribed a variety of functions, and Wilson [27] has even ventured to attribute to the corpus striatum and its primitive projection system a function of control over cortico-spinal innervation, evolutionary and phylogenetic conceptions notwithstanding.

Physiologists, too, have obtained remarkable results. Rothmann, particularly, and Schafer [19] by extirpation of the motor cortex, transection of the pyramids in the medulla and division of the lateral and ventral tracts of the cord, singly and in various combinations, have demonstrated how transient is the motor disability following interruption of the pyramidal system, and how extensive a rôle is played by other efferent paths.

Using the chimpanzee, Sherrington and Graham Brown [23] find that following excision of the "arm area" of the cortex, complete restoration of function in the corresponding limb is attained within a few weeks. Moreover, they were able to exclude a vicarious activity in this respect of the corresponding post-central or the crossed precentral cortex.

The basis of restoration of function in man after lesions of the pyramidal system is difficult to determine, both from the nature of the diseases studied and from the limitations of the clinical method. Whether return of power in these cases is due to regression of the original pathological process, and resolution of diaschisis (v. Monakow), or to vicarious functioning of other and intact portions of the nervous system (Munk), is commonly impossible of determination. Horsley's [12] well-known observation on a case from whom he had removed the arm area of the precentral gyrus indicates that in man also some degree of vicarious restoration must obtain apart from recovery due to the factors proposed by v. Monakow. Horsley concludes that "so-called volitional movements are not alone generated

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and in both instances de-afferentation abolishes the rigidity (Förster's operation in man).[1]

Whether spasticity in man presents to the same degree the plastic quality described in decerebrate rigidity may be questioned. The striking modifications of attitude produced by Forster in spastic limbs indicate a certain measure of plasticity. Probably the slower development and long duration of spastic conditions in man, resulting as they do in prolonged immobility and secondary changes in the muscles, may help to diminish this quality.

It may be considered extremely probable also that the minimal metabolic activity characteristic of the muscular contraction in decerebrate rigidity (Roaf, Bayliss) would be found to obtain in spastic conditions in man.

As yet, it can be scarcely profitable to discuss in this connexion the dual nature of tonus postulated by de Boer, Boeke and Langelaan. The recent observations of Cobb [7] provide no evidence that decerebrate rigidity is in any way concerned with sympathetic innervation.

(c) *The Anatomical Basis of Spasticity and of Decerebrate Rigidity.*

At first sight a serious obstacle to the identification of spasticity with decerebrate rigidity is presented by the observations of Sherrington [20] and of Weed [26], working in the same laboratory, that following unilateral decerebration the resultant rigidity is homolateral, not crossed as in hemiplegia.

According to Sherrington, the development of rigidity is somewhat inconstant after unilateral decerebration, and is mainly homolateral, and Weed obtained similar results. However, light is thrown upon this point by Thiele [24] who, using the method of successive (unilateral) coronal sections, found that rigidity appeared when the plane of the caudal extremity of the thalamus was reached, and is then contralateral. He says: "If the transection was made far forwards in the region of the optic thalamus and the anterior corpora quadrigemina marked contralateral rigidity was produced, the homolateral limbs were scarcely at all affected and then the rigidity occurred in them later and only on manipulation of the limbs. When the lesion was made farther back in the region behind the corpora quadrigemina the homolateral rigidity was obtained with only slight contralateral. These facts point to the conclusion that the influence descending from the thalamus is a crossed one, and that the decussation takes place high up in the region of the decussation of the rubrospinal tract."

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[1] Since completing this paper a lost reference has been refound, and is so apposite, and expresses so clearly what may be found in the vasti muscles in any spastic extended leg, that I quote it in full.

Discussing the plastic tone of the decerebrate animal as seen in the "lengthening reaction" of the vasto-crureus, Sherrington remarks that "when the forced flexion is begun resistance, even considerable, is felt opposing it. The extensor muscle's tonic contraction refuses, so to say, to yield. But under continuance of the strain this resistance almost suddenly subsides; the tonic contraction of the muscle abruptly gives way, the resistance from that moment onward is less; the flexing of the knee and the forced stretching of the muscle meet with little further opposition"—*Quarterly Journ. Exper. Physiol.*, 1909, ii, p 109.

Confirming this is Sherrington's observation that decerebrate rigidity can be inhibited in a given muscle group by stimulation of an appropriate point in the crossed motor cortex [20].

Farther, since the mesencephalic excitation experiments of Thiele, Weed and others indicate the red nucleus and rubrospinal tract as the point of departure and the conductor respectively of the efferent impulses subserving decerebrate rigidity, such a crossed relationship seems inevitable. The encephalic connexions of the red nucleus are uncrossed, its cerebellar and spinal connexions crossed.

The cortical point, stimulation of which inhibits the rigidity, is that from which excitation of the antagonist of the inhibited muscle is obtained (under reciprocal innervation).

Therefore both anatomical and physiological considerations indicate that decerebrate rigidity is dependent upon removal of a crossed cerebral control.

(d) *The Special Position of the Upper Limbs in Man.*

In quadrupeds the fore limbs share the locomotor function with the hind limbs, and we find accordingly, in the decerebrate animal, the same extended position in both fore and hind limbs; that is, the same incidence of the postural tone.

In man, erect and bipedal, the conditions are quite different. The upper limb has been promoted "from a simple locomotor prop to a delicate explorer of space in manifold directions" (Sherrington [21]).

There is abundant evidence that the mechanism of progression is laid down in lowest level centres, and in such a mammal as the cat is capable of functioning at birth, like the respiratory centre (Graham Brown [4]).

In this respect the upper limb in man is very differently placed. Its functions are largely acquired under the dominance of the cerebrum.

If it can be said to possess a primary inherent function it is that of embrace, grasping, and of carrying food to the mouth. In these primitive movement complexes, the limb flexors fulfil a purpose analogous with that of the extensors engaged in the postural extension reflex in the hind limb.

These *a priori* considerations gain significance when we study the attitude of the upper limb in hemiplegia. In this condition the typical position of the limb is one of flexion at all joints with adduction and semipronation. In tetanus spasms, and in the "tetanus-like seizures" of Hughlings Jackson, the arms are rigidly flexed; the legs rigidly extended.

The spasticity of the upper limbs, its incidence in the flexors excepted, resembles in all respects that found in the lower limbs.

Of no less interest is the relatively poor recovery of the upper limb in hemiplegia, when compared with that sometimes found in the lower limb in a given case. These points indicate not only that the incidence of the postural tone has changed with the altered functional conditions, but also that the upper limb is more dependent on cortical control and innervation than the lower limb, which is still engaged in its primitive locomotor function.

It is noteworthy that in the frog, in which the habitual posture of the hind limbs is one of flexion, the postural tonus is a flexor tonus (Sherrington [22]).

Perhaps the absence in the spastic upper limb of any reflex analogous with the nociceptive flexion reflex of the lower limb is another expression of the altered innervation and functional relationships of this limb in man.

The view advanced previously [25] and in this paper may, then, be summarized as follows: The spasticity of spastic paralysis as seen in hemiplegia and in paraplegia in extension is analogous with the decerebrate rigidity of Sherrington. It is, therefore, an expression of the activity of the proprioceptive system taken as a whole. This system induces a tonic reflex, which, unmasked in the decerebrate animal, has been shown to possess the significance of a postural reflex—reflex standing. In man also we see in hemiplegia a rigidity which has the same significance. However, in this instance, the upper limb shows typically an attitude of flexion; the hypertonus is resident in the limb flexors, not in the extensors as in the lower limb.

This may be traceable to the altered functions the upper limb exercises in man, and to its complete lack of the locomotor function.

III.—FÖRSTER'S THEORY OF THE ORIGIN OF SPASTICITY.

Reference has been made earlier to other hypotheses of the origin and nature of the spasticity seen in spastic paralysis. No one of these takes cognizance of the principles laid down by Hughlings Jackson, or of those fundamental conceptions of the reflex activity of the nervous system we owe to Sherrington. We cannot therefore expect, nor do we obtain, much enlightenment from them.

It is to Förster that we owe the demonstration that de-efferentation of spastic muscles abolishes their rigidity. This is the basis of his operation of posterior root section, and forms the starting point of his theory of the pathogenesis of spasticity in pyramidal lesions [8].

He believes that the pyramidal tract exercises both excitatory and inhibitory functions. The latter consist in the "imbibing or sucking up" of the excess of afferent impulses which reach the ventral horn cell. He says: "If this inhibition fails, the unimpeded sensory afflux charges more and more the anterior horn cell, increases its excitability, and produces a permanent motor stream from the ganglion cell to the muscle, that is to say, the spastic contracture."

So much for causation; as for the selective incidence of the spasticity he states: "Whether this or that muscle group is subject to contracture or not depends on external conditions, and this condition consists exclusively in the degree of approximation of the points of insertion of the muscular-group, or, in other words, the position of the limb in question. The muscular group, the points of insertion of which are at a maximum distance, shows no spasticity."

Three subsidiary factors in turn are invoked to determine the necessary position of the limb: the action of gravity, involuntary movements caused by sensory stimuli ("Abwehrbeugereflexe"), and the distribution of the residual voluntary mobility.

From this it follows that the incidence of spasticity, and hence the attitudes of the spastic limbs, are entirely dependent on external and capricious factors, and Förster claims that he can change the incidence of the spasticity at will by modifying the position of the spastic limb.

Against the value of these multiple and uncertain factors, the absolute constancy to one or two types, under ascertained internal conditions, of all cases of spastic paralysis is the strongest indication.

Further analysis shows that in each element Förster's hypothesis is incompatible with the facts.

The dual function ascribed to the pyramidal tract is not, it will be seen at once, in accordance with those processes of reciprocal innervation which we know motor cortex reactions to show, nor with the modern conception of the origin and nature of muscle tone. Förster regards the latter as the functional expression of a purely spinal reflex arc. We know that this is not the case.

Further, it seems clear that the factors determining the incidence of the spasticity, and hence the attitude of the limb, are internal, not external and adventitious. Thus only can we account for the transformation of a paraplegia in extension to one in flexion. There is some evidence that passive position may have a modifying influence in this respect; Sherrington has found it so in animal preparations, but none that it is the determining factor.

This point was made the subject of investigation by Dr. F. E. Batten, at a time when I was his house physician at the National Hospital, Queen Square.

A case of infantile spastic diplegia with rigid, extended legs, adductor spasm and "scissors gait" was put up in plaster in a position of as extreme abduction as was compatible with comfort. The legs were slightly flexed at knee and hip. This position was maintained for sixteen days.

On taking the limbs out of the plaster, they were found to maintain an abducted and slightly flexed attitude. Passive adduction met with slight tonic muscular resistance, and Förster's conclusion seemed confirmed, but within two weeks the original adducted and extended position had spontaneously returned with all its old intensity. It was evident that the determining internal factors had soon overset the external and adventitious ones.

As a determinant of attitude, gravity can scarcely be invoked as responsible for the flexed adducted attitude of the arm in hemiplegia, which indeed is a permanent defiance of gravity, nor in hemiplegia do the "Abwehrbeugereflexe" determine the incidence of the spasticity.

They are, as I have shown, due to the activity of a reflex system involving other muscles than those engaged in the maintenance of reflex tone. Reflex movements and spasticity stand in no causal relationship one to the other, but are both the result of loss of cerebral control over lower level reflex systems.

Involved in Förster's theory is still another subsidiary factor introduced to account for the form and genesis of the "Abwehrbeugereflexe"—indeed, the multiplicity of the causes invoked to account for a set of phenomena readily traceable to a single cause that constitutes the inherent weakness of all the current hypotheses on this subject.

IV.—The Proprioceptive System and the Cerebellum.

(a) *The Position of the Cerebellum in the Proprioceptive System.*

If we accept these conclusions, it will be seen that the importance thereof lies not alone in the elucidation of the origin and significance of a group of symptoms, but even more in the fact that in these phenomena we are studying the activities of one of the "extra-pyramidal motor systems."

It is important, therefore, to elucidate as far as possible the anatomical basis of these symptoms. The question of the crossed relation of the cerebrum to the rigidity has already been discussed.

The reflex arc itself in decerebrate rigidity we may construct with reasonable certainty from the observations of Sherrington, Thiele and Weed. The afferent impulses upon which the rigidity depends arise in the muscles concerned, reach the cord by the posterior roots and pass up in the ventrolateral column on the same side of the cord. From the researches of Weed it seems extremely probable that the cerebellum is an important and essential link in the reflex arc. There is evidence that, following the course taken by the spino-cerebellar fibres of Gowers' tract, the afferent impulses reach the cerebellar cortex via the superior cerebellar peduncles. The efferent arm of the arc leaves the cerebellum by the same route, its descending arm being cerebello-rubrospinal.

This is of some interest in view of the functions which various clinical observers have ascribed to the rubrospinal tract.

Although in man we can scarcely hope to obtain such extensive information as to the separate links in the reflex arc of which spasticity is the functional expression, certain significant facts are known. That it arises in the muscles themselves is seen by its abolition when these are de-afferented (Förster's operation), and, as I have pointed out in my previous paper, the efferent link of the arc is resident in extra-pyramidal paths.

There are indications, too, that the cerebellum is an essential link in the chain, and upon the whole it seems reasonable to suppose that just as spasticity resembles decerebrate rigidity in character and incidence, so its anatomical substratum is the same.

(b) *The "Corresponding Opposite" of Spastic Paralysis.*

The condition of maintained muscle tone in the decerebrate animal is regarded by Sherrington as one expression of what he has called the proprioceptive system. The physiological significance of this, so comprehensively described by him in many papers, need not now be discussed except in so far as concerns the cerebellum, the position of which in this system is of primary importance in our present connexion.

Sherrington's conception is that the labyrinth is the proprioceptor of the head segments, and that the cerebellum may be regarded as the central nervous mechanism of this receptor, which, like the other receptor organs of the head, tends functionally to dominate the segmental receptors.

Concordantly with the fact that the labyrinthine proprioceptors are the most important, the central mechanism is an organ of high complexity. It receives the vestibular nerves and also internuncial paths from all the segmental proprioceptors and is "the chief co-ordinative centre, or group of centres, of the reflex system of the proprioceptors" [21].

Proprioceptive reflexes are typically secondary to exteroceptive reflexes, which they may reinforce or inhibit, and in restoring the posture transiently overset by phasic exteroceptive reflexes, they have also a compensatory action. The proprioceptive system, then, maintains and regulates tonus in the "antigravity muscles."

In Sherrington's original observations on the decerebrate animal he found that ablation of the cerebellum did not abolish the rigidity [20].

This is scarcely what would have been expected in view of the position in the proprioceptive system of this organ. That its removal should leave the reflex system, of which it is at once the great co-ordinating centre and a component part, in unimpaired function is difficult of comprehension.

It is very significant, therefore, that, in agreement with the observations of Horsley [13], Weed finds that ablation of the cerebellum and procedures calculated to impair its activity abolish an established rigidity, and prevent the appearance of rigidity on subsequent decerebration [26], and he concludes that the cerebellum forms a very important, if not essential, pathway for the afferent impulses from the limbs and trunk concerned in decerebrate rigidity; and Sherrington [22], discussing these experiments, states that they indicate that "the cerebellum commonly lends this reflex a large amount of support and refined adjustment."

If we may conclude that the cerebellum is an essential link in the proprioceptive reflex arc we are brought nearer again to Jackson's conception of "cerebellar influx," even though we now recognize the reflex origin of the rigidity.

But we may still follow Jackson with advantage in our consideration of this problem, and in doing so the purpose of this digression into the functions of the proprioceptive system will become apparent.

One of Jackson's observations was that "certain cerebral and cerebellar maladies may be contrasted and compared with one another as being complementary inverses (corresponding opposites)."

Beginning, then, with our conception of the origin and nature of spasticity, we may endeavour to determine on theoretical grounds what the "corresponding opposite" of spastic paralysis would be.

On the negative side, we should expect to find atonia in previously tonic muscles from loss of the proprioceptive postural tonus, while on the positive side we should anticipate certain disorders of voluntary movement depending, also, on the lapse of this involuntary reflex mechanism of co-ordination.

Further, assuming that the cerebellum is an essential pathway in the reflex arc which is responsible for the spasticity in hemiplegia, and of which the rubrospinal tract appears to be the descending limb, it seems reasonable to suppose that cerebellar disease, in that it would constitute a breach in the reflex arc of the proprioceptive system, should provide us with this "corresponding opposite" of spastic paralysis. In effect, this corresponding opposite would be the equivalent of an extrapyramidal motor disease, since it would put out of action the cerebello-rubrospinal path.

We cannot but be struck, therefore, by the completeness with which, in fact, cerebellar disease fulfils these conditions.

In this connexion the comprehensive study of acute cerebellar lesions by Gordon Holmes [11] forms an admirable standard by which we may compare the two. On the negative side we see a pronounced atonia of the musculature. Loss of power is minimal and transient: "an asthenia rather than a paresis."

On the positive side there is the composite picture of cerebellar ataxy.

Now although Sherrington's conception of the position of the cerebellum as a reflex centre may in the abstract have found acceptance, yet it cannot be said that it is as a link in the proprioceptive system that this structure is commonly regarded by neurologists in discussing its symptomatology.

Yet clearly this aspect is of the greatest importance to an appreciation of the physiological significance of cerebellar disease.

It is interesting to speculate in how far we may expect voluntary movements to be disordered when the reflex activity of the proprioceptive system considered as a whole is in abeyance.

Gordon Holmes expresses the view that while atonia may account for the "rebound phenomenon" described by him and Grainger Stewart, it cannot produce the various components into which the cerebellar ataxy has been divided. It is clear that unless we adopt the modern conception of muscle tone, that we owe to Sherrington, we cannot readily correlate atonia with the ataxy of a cerebellar lesion. Yet in the light of this conception the matter seems less obscure.

The reinforcing, inhibiting and compensatory functions exercised by the proprioceptive system in respect of phasic exteroceptive reflexes have already been referred to, and it becomes apparent that in every voluntary co-ordinated movement the tonic postural reflex is an integral and essential element. There is, to use Jackson's phrase, "a perfect co-operation of antagonism" between the phasic and the underlying tonic elements in the innervation.

The atonic musculature of cerebellar disease is one from which this essential element in co-ordination has fallen out, and all movements carried out by it lack those elements of co-ordination we have mentioned, reciprocal innervation is necessarily overset, and we may regard the atonia and the ataxy as the negative and the positive expressions respectively of the same defect.

As I have suggested earlier, several factors go to the performance of a co-ordinated voluntary movement. Some of these are purely reflex and entirely subconscious. Such, for example, is the reflex mechanism under discussion. These various mechanisms cortico-spinal innervation regulates and throws into action. Should one of them fall out, voluntary innervation must of necessity be disordered, for the individual has voluntarily to compensate for and to reproduce this unconscious element in his co-ordination.

He is like a man mounted on a bicycle for the first time, and he comes similarly to grief.

We may, therefore, see in an interruption of the proprioceptive reflex arc an explanation of the atonia and of the motor disorders of cerebellar disease.

Whether the resolution of cerebellar ataxy into such components as asynergia, dysmetria, decomposition of movement and tremor has other than a purely conventional value is somewhat open to question, if this view be correct. It seems probable that they are better considered as passing aspects of a single defect than as distinct and separable defects.

The somewhat arbitrary dissection of cerebellar ataxy into numerous and often overlapping components might even be regarded as calculated to obscure its underlying significance, since, as Sherrington points out, fractional reactions are always more difficult of interpretation than wider and more extensive movement complexes.

To summarize: Viewed in the light of Jackson's teaching and of the physiological researches of Sherrington, there appear good grounds for regarding the cerebellum as an important link in the reflex arc subserving the rigidity of hemiplegia. We may, then, look for the "complementary inverse" of spastic paralysis of corticospinal origin in lesions involving the cerebellum. Both clinical and experimental observations demonstrate how completely these lesions may produce such a contrasted picture.

In that the cerebello-rubrospinal path appears to be the efferent limb of the proprioceptive reflex arc, we may regard the motor disorders following its inactivity, which cerebellar disease entails, as an example of an extrapyramidal motor disease.

V.—Associated Movements in Hemiplegia.

There is still another feature distinguishing spastic paralysis from its "corresponding opposite." In hemiplegia there is seen a group of involuntary phenomena known as associated movements (Syncinésies, Mitbewegungen). These form no part of the symptom-complex of cerebellar lesions, and it seems reasonable to regard them as probably arising in the same mechanism that is responsible for the production of spasticity in hemiplegia.

Innumerable classifications and descriptions of these are to be found in the literature of neurology, but very little profit is obtainable from their study. Reference to the large number of papers on this subject that have appeared in the *Revue Neurologique* during recent years reveals the fact that movements of widely differing origin and character have been included within the term "syncinésies," and we readily recognize certain of the reflex movements studied in my previous paper. In their full and minimal forms both flexion and crossed extension reflexes find place in these tedious classifications, which do not even agree as to the morphology of the movements they describe.

It seems better, therefore, to approach the question from the point of view hitherto adopted in this paper, than to do so trammelled by conflicting hypotheses that have but one point in common—that they completely ignore all that we have learned in recent years of the physiology of the nervous system.

An essential condition of the production of an associated movement is a voluntary or involuntary movement of the normal half of the body. Any forceful movement of one of the normal limbs, or such involuntary bilateral movements as yawning or coughing, will in a typically spastic hemiplegia evoke an associated movement on the hemiplegic side. In the spastic upper limb, following a strong grasp of the normal hand, we see a slow but powerful flexion at elbow and distal joints, sometimes associated with elevation and abduction at the shoulder. More rarely an equally slow, maintained extension of the limb occurs, with extension and fanning of the digits.

Throughout the series of cases of hemiplegia that formed part of the basis of my previous paper, I was unable to satisfy myself that there was any constant relationship between the form of the voluntary movement and the involuntary crossed movement it evoked. The two were neither constantly symmetrical nor constantly opposite in character; voluntary extension of the normal limb was as often followed by associated flexion as was voluntary flexion.

In a given case the form of the associated movement varied but little whatever the form of the voluntary movement evoking it.

Noticeable, however, was the fact that such a bilateral movement as yawning usually produced extension of the upper limb with fanning of the digits as associated movement, and the conclusion seemed justified that *crossed* associated movements of the upper limb were usually flexion, and that following *bilateral* movements associated extension predominated.

In the lower limb an increase of the extensor rigidity was the usual associated movement. Here, as in the upper limb, the involuntary movement bore no particular relationship as to form with the voluntary movement. No definite evidence of a progression type of movement was obtained.

Nor is it easy to say whether these movements show any degree of co-ordination; that is, of reciprocal innervation. Such information as is obtainable from palpation would incline me to answer this question in the affirmative. Many writers state that the muscular contraction is global, involving all the limb muscles, attitude being determined by the more powerful group. How they reach this conclusion is not indicated.

Clinically this point is difficult of determination in the upper limb, where these movements are best studied.

A feature of associated movements is their slow *crescendo* development, and their equally slow recession when the evocative movement has ceased.

It would be easy to follow precedent in the study of these movements and to subdivide them into symmetrical and asymmetrical, or, into global, co-ordinative and imitative (Marie and Foix [16]), and so on, and to evolve a separate pathogenesis for each type (herein also following Marie and Foix).

But, as I have observed earlier, analysis of this type is as apt to obscure the issue as to throw light upon it. To endeavour to trace the varying forms these movements take to a common source seems a more profitable procedure than to subdivide and classify them, and to devise an hypothesis for each.

Whether symmetrical or asymmetrical, flexor or extensor, these movements consist in *accessions of tone* into muscle groups for the most part already hypertonic, but occasionally, as in associated extension of the arm in hemiplegia, into muscles not previously tonic.

It is in this sense, rather than as movements, that I would consider them.

If we turn to the consideration of the decerebrate animal, we find that excitation of the red nucleus area on the cut surface of the midbrain evokes characteristic reactions (Thiele, Weed, Graham Brown), whether the animal be cat or chimpanzee. The typical reaction is flexion of the homolateral fore limb and crossed hind limb with extension of the crossed fore limb and homolateral hind limb. Less commonly bilateral extension or flexion may be elicited, and throughout a series of observations on a single preparation variations of this kind may occur.

Characteristic of these movements is their slow initiation and recession. Thiele [24] says that these movements require stronger stimuli for their elicitation than do movements obtained by stimulation of the cut surface of the pyramids, and are much slower and coarser than these.

In the chimpanzee Graham Brown [3] finds that "these movements having attained their maximum tend to be maintained long after the cessation of the evocative stimulus."

Stimulation of a single red nucleus area produces bilateral movements.

It seems possible that in these coarse transient modifications of the rigidity we see a deformed expression of the posture regulating functions of the reflex arc of the proprioceptive system, elicited under crude excitation of the red nucleus, and not associated with the cerebral co-operation and control normally present in the intact animal.

Now though it must remain at present in the realm of speculation, I venture to suggest an analogy between these red nucleus reactions and the associated movements of hemiplegia.

Sherrington has shown that when a limb is employed in any active movement or series of movements, it is a function of the proprioceptive system to maintain the rest of the skeletal musculature in an adequate posture by a widespread synergic action of the musculature it controls. This involves muscles of both halves of the body equally, though not necessarily in symmetrical attitudes.

In the intact individual this is carried out under the co-ordinating and regulating activity of the cerebrum: a bilateral cortical control.

If, as in hemiplegia, one cortico-spinal path is out of action, then control over the crossed postural reflex is in abeyance, and on voluntary movements of the intact half of the musculature, especially forceful movements, such as demand widespread synergic fixation, there occurs the usual bilateral postural adaptation through the action of the intact proprioceptive reflex system. Freed from cerebral control on the paralysed half of the body, this is manifested as a crude associated movement, which thus consists in a transient modification of the spasticity.

If the view adopted here of the nature of spasticity be correct, such a phenomenon as associated movement is a reaction of the postural reflex system that might have been foretold.

In this way associated movements after crossed voluntary movements, and after bilateral involuntary movements such as yawning, are readily comprehensible. Their origin and character are both in accord with such an hypothesis.

VI.—THREE COMPONENTS IN MOTOR INNERVATION.

So far we have considered the activity and interrelationships of three of the components in the motor innervation of the skeletal musculature: cortico-spinal, mesencephalo-spinal (proprioceptive system) and spinal (also a reflex system).

In spastic paralysis we have a composite picture in which the voluntary cortico-spinal element is wanting. In cerebellar disease, it was submitted, the proprioceptive system is in abeyance, while, as was indicated in my previous paper, in paraplegia in flexion and in the symptom-complex of complete transverse cord lesions we have solely the residual spinal reflex activity.

With regard to the last named, paraplegia in flexion was identified as the expression of purely spinal reflex activity, free from the obscuring effects of spinal shock and isolation dystrophy.

This view has since received conclusive proof in the study of cord transections from gunshot wound by Head and Riddoch, and by Riddoch separately in a parallel research. By what must have been an unexampled care of their patients, these observers were able to minimize the effects of spinal shock and to retard the development of dystrophic changes, and they have been able to observe well-developed spinal reflexes, protective, locomotor, visceral and procreative in character, whereas in my more limited observations I was only able to detect minimal traces of the nociceptive flexion reflex.

They have proved for man, therefore, what Sherrington has been able to demonstrate for animals, that " spinal reflex movements suggest fairly obvious protective, procreative and visceral functions on the one hand, and on the other the main movements of the progression habitual to the animal. They seem to refer to stimulation of nociceptive or sexual skin nerves, or visceral afferent fibres as though initiated by these."

In this connexion it is interesting to recall an observation of Broadbent's in 1903, which subsequent research has abundantly justified: " I do not think the human cord is inferior in its essential endowments to that of the frog, and although it loses its independence by its subordination to higher centres it retains in my opinion all its potentialities " [2].

The Supremacy of the Cortico-Spinal System.

Deferring for the moment the consideration of other probable components of the efferent path, we may draw some conclusions as to the supremacy of the cortico-spinal component from our study of those already discussed. Their relative position seems accurately stated according to Jackson's conception of "levels" in the nervous system: The cortico-spinal system appertaining to the middle level, and the proprioceptive and spinal reflex system to the lowest evolutionary level.

A similar conception is expressed by Sherrington. Tracing the development of the cerebrum under the influence of the distance receptors, visual, auditory and olfactory, he has indicated the predominant position of these receptors and of their central nervous mechanism, the cerebrum, as the "great inaugurators of reaction" and the "preponderant directive influence over the whole nervous system." He says: "The rest of the animal, so far as the motor machinery goes, is but the servant of them" [21].

The pyramidal tract is the path by which this motor machinery is controlled by the cerebrum, in man at least. *Loss* of voluntary power can be produced by its interruption, and by this alone, and not by that of subordinate components of the efferent path. Destruction of these can only produce *disorders* of voluntary movement.

The genesis of some of these disorders we have yet to discuss, but the point I would raise now is that because a negative lesion of an extra-pyramidal path "allows" tremor, ataxy, or rigidity, we must not conclude therefrom that such a path exerts a controlling or inhibiting function with respect to cortico-spinal innervation.

The falling out of a subconscious reflex mechanism—proprioceptive or otherwise—must of necessity disturb co-ordination, simply because the nervous mechanism through which cortico-spinal innervation produces its effects on the musculature is defective. To conclude with certain writers that cortico-spinal innervation is controlled or "steadied" by efferent systems of lower level, that is, of subordinate physiological position, is to reverse our conceptions of evolution in the nervous system, and to miss the true significance of the motor disorders in question.

VII.—On the Tremor-Rigidity Syndrome of Paralysis Agitans and other Organic Cerebral Lesions.

A certain physiological significance has been revealed in the positive symptoms studied in the preceding chapters of this paper.

The three symptom-complexes described may be regarded as examples of dissolution in the middle and lower levels of the nervous system, in each of them one or other integrative element having fallen out of its appropriate evolutionary level.

The analysis of these phenomena was largely based on indications offered by the experimental physiology of the nervous system, above all by the work of Sherrington.

When we pass to the consideration of those other disorders of motor innervation—athetosis, chorea, and the tremor and rigidity characteristic of paralysis agitans and of certain basal and midbrain lesions—we

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find ourselves in much more difficult country. Here physiology offers us no direct and unequivocal indications.

It is not proposed to consider these disorders at length in the present paper. Since the analysis of them by Gordon Holmes in 1904 there is little that is new to be said, nor can we yet indicate their pathogenesis or their significance, physiologically considered, with any certitude.

Yet we may select two of the most extensively studied of these for a brief general consideration from the point of view hitherto adopted here.

The couple, tremor and rigidity, seen in paralysis agitans appears to present the same characteristics and to be identical with that described in the midbrain lesions analysed by Gordon Holmes, and that occurring in the corpus striatum syndrome (progressive lenticular degeneration) of Kinnier Wilson.

The tremor in question has been defined by Holmes as a rhythmic involuntary oscillation of a limb or a part of a limb due to the alternate contractions of one group of muscles and its antagonists.

The rigidity characteristic of these conditions differs entirely from that following hemiplegia in being diffuse in its incidence and uniform in character throughout the whole range of movement. One might adapt an expression used by athletes and describe the victim of this condition as "muscle-bound." To the significance of these features it will be necessary to return later.

It is true that these symptoms have been localized to certain more or less circumscribed areas of the brain, but it is a long and as yet untrodden path, from their localization as symptoms to their identification as expressions of function, or, in other words, to the determination of the functions of the organs in which disease has evoked them.

We may agree in regarding them, following Jackson's teaching, as positive symptoms and due, therefore, to the disordered activity of intact centres unbalanced by reason of functional defect in other systems or centres. (Perhaps it might be more precise to say that they represent the algebraical sum of the activities of several centres, one or more of which are functioning subnormally or not at all, while the rest are correspondingly superactive.)

In an attempt to determine the motor centre, or centres, which are acting excessively and irregularly and so producing these symptoms, we may derive some assistance from our earlier observations.

In studying the spasticity and reflex movements in hemiplegia and in the two types of paraplegia, we noted that, although exaggerated and uncontrolled phenomena, they yet bore a clear imprint of their origin and their physiological significance, and *in this respect they were characteristic of the reflex systems in which they arose.* Thus, spasticity in hemiplegia, distorted expression of proprioceptive reflex activity though it be, yet shows the fundamental characters of a co-ordinated purposive reflex activity that betray its origin. This is also true of the reflex movements we studied.

In the tremor and rigidity of paralysis agitans we can as yet see no such physiological analogy. They appear purposeless and inherently pathological.

Let us consider the rigidity from this point of view. It clearly does not arise from the activity of the proprioceptive system, which we have regarded as the source of the spasticity of hemiplegia. We have studied this system, both clinically and experimentally, in states of exalted and of depressed activity, and it has revealed nothing comparable with this diffuse rigidity, which shows no germ of co-ordination whatever.

From the fact that the cortico-spinal system is intact in these diseases it has been supposed that its overaction produces both tremor and rigidity. Thus, Gordon Holmes [10], discussing them as they arise in certain midbrain lesions, concludes that they are due to a negative lesion of the cerebello-rubrospinal path, which he suggests normally exercises a co-ordinating influence on cortico-spinal innervation. When this fails cortical overaction produces tremor.

Wilson [27], from the study of progressive lenticular degeneration, advances a very similar view. The basis of his hypothesis is the localization of these symptoms (among certain others) in a bilateral degenerative lesion of the lenticular nucleus and its projection system.

He concludes that: " (1) The corpus striatum exercises a steadying effect on the action of the cortico-spinal system. (2) This is effected either by the lenticulo-rubrospinal system, or more indirectly via the optic thalamus and its cortical connexions. (3) When this influence is impaired pyramidal function is affected in its turn, and is seen in hypertonicity or rigidity, as well as in tremor or voluntary movement. . . . (8) Tremor is due more particularly to failure of function of the lenticulo-rubrospinal system. (9) Hypertonicity or rigidity, due to defect of the 'inhibitory' action of the corpus striatum, is possibly associated with impairment of impulses from that body via the optic thalamus to the cerebral cortex." This, he adds elsewhere, "makes the cortical motor cells react in such a way that one of the results is increase of tonicity of all the muscles innervated by the pyramidal tract."

Certain difficulties meet us when we consider these hypotheses in the light of conclusions reached earlier in this paper.

Considering first the negative aspects of these views, we note with Gordon Holmes [10] that "the cerebello-rubrospinal path is one of the most definite and direct routes by which the cerebellum may influence the lower motor centres." We should therefore expect its interruption to produce a clinical picture more or less closely resembling that of a cerebellar lesion.

If this path be the efferent link, as we have supposed, of the proprioceptive reflex arc, it is surprising that its interruption should be followed not by atonia and ataxy, but by tremor and rigidity.

In midbrain lesions there must always be difficulty in determining which, among the several paths necessarily involved by an extensive lesion in this crowded thoroughfare, really underlies the symptoms resulting, and we cannot exclude the possibility of some other local source than that suggested by Gordon Holmes.

On the negative side Wilson's hypothesis suffers from a certain vagueness and lack of precision in its enunciation. We do not know precisely what may be comprehended in "a steadying effect." We cannot readily express this conception in physiological terms. It must, at least, include what we know as "reinforcement" and "inhibition." Phylogenetically, the corpus striatum is much older than the corticospinal system, and must therefore have assumed this new function of control over the latter quite late in the evolutionary history of the nervous system.

From what has been said earlier of the dominance of the cerebral cortex and its projection system, such a view of the function of a primitive and physiologically depreciated organ as is the corpus striatum can scarcely be maintained.

On the positive side there are certain objections to regarding a diffuse muscular rigidity as the expression of a cortical overaction, nor is any light thrown on the subject by such a vague general statement as that "the motor cortical cells react in such a way that one of the results is tonicity of all the muscles innervated by the pyramidal tract" (Wilson).

Recalling Jackson's conception of "cerebral influx," as changing

and not continuous, and Sherrington's observation that cortical reactions are phasic, and not tonic, and, moreover, that they exhibit reciprocal innervation, and, considering also that the motor cortex discharges of Jacksonian epilepsy are clonic, we shall find it hard to recognize in a rigidity involving the whole skeletal musculature indifferently, even the distorted expression of cortical activity. For, if this is so, then cortical action is altered not only quantitatively, but also qualitatively.

We are not helped at all by supposing that "rigidity is tremor run together," and that tremor is a phasic activity reminiscent of cortical action. For *if we accept the definition that tremor is due to alternating contraction of antagonistic groups of muscles, then this rigidity differs qualitatively from tremor*, since the rigidity seen in paralysis agitans exhibits no such trace of reciprocal innervation.

Another objection to the theory of "cortical overaction" is that these symptoms do not depend so entirely on voluntary innervation for their appearance—though they are naturally modified by it—that we are justified in saying that they have no other source.

We may conclude, therefore, that the view attributing the tremor and rigidity under discussion to uncontrolled cortical action is not established, and is contra-indicated by such knowledge as we possess of the normal activity of the motor cortex.

It would take too long to analyse the theory elaborated by Ramsay Hunt [14] to account for the paralysis agitans syndrome. The hypothesis is quite incompatible with what we now know of the physiology of such reflex acts as progression and muscle tone, and, therefore, the the theory of the functions of the corpus striatum, erected upon the localization of these symptoms to a degeneration of this structure in a case of juvenile paralysis agitans, cannot be entertained.

There is absolutely no meaning in such a statement as that "retropulsion" in paralysis agitans is due to "attempting to walk under the guidance of the cortical and cerebellar mechanisms without the safeguard of the corpus striatum, which normally regulates such acts." We know that there is a perfectly co-ordinated mechanism for this movement complex quite apart from the corpus striatum, while, on the other hand, there is no evidence that this organ has anything to do with it; while the naive creation of "an inhibitory tremor centre" in the hypothalamic region, which, when liberated from the control of the diseased corpus striatum, contrives in an unaccountable manner to *produce* the tremor of paralysis agitans, is perhaps, the most amazing feature of this "contribution to the functions of the corpus striatum."

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THE PATHOLOGICAL EXAMINATION OF FORTY INTRACRANIAL NEOPLASMS.[1]

By J. GODWIN GREENFIELD, M.B., M.R.C.P., B.Sc.

From the Pathological Laboratory of the National Hospital for the Paralysed and Epileptic.

INTRODUCTION.

THE opportunity was recently offered on the reopening of the Pathological Laboratory of the National Hospital for the Paralysed and Epileptic, after a temporary closure due to the war, to examine, at the same time, a number of specimens of intracranial neoplasms which had collected there, brought from the operating theatre and the post-mortem room. To these have been added a considerable number which came to the laboratory while the examination was being carried on, bringing the total up to forty in all.

It was found impossible to examine some of the older tumours owing to imperfect preservation, so that any statistics given below are only roughly those of a consecutive number of intracranial growths.

In three cases the tumours affected the spinal cord as well as the brain, but tumours affecting the cord alone have not been included. Those cord tumours that have been examined were not of any special interest, and do not throw any light on any of the problems which the present series of intracranial tumours has raised.

The investigation of these tumours has been undertaken purely from the pathological side, and where clinical notes are included it is only to give some idea as to the age and rate of growth of the tumour.

Beyond that no attempt has been made to link together the clinical symptoms and the pathological findings.

The chief object of the present report is to make some attempt, by the investigation of a fairly large series of tumours of the brain, to clear up some of the anomalies of nomenclature which are found everywhere in the literature dealing with the subject, and to discuss, in relation to the findings in the cases examined, the nature of certain groups of tumours peculiar to the nervous system.

The present moment is a particularly favourable one for the purpose,

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[1] Report to the Medical Research Committee.

as recent work has brought to a head the old controversy associated with the names of Virchow, von Recklinghausen, and Durante, and although it is still far from being decided, opinion seems to be coming round to accepting Verocay's term "neurinoma" for the tumours which Virchow called "neuromata," von Recklinghausen "neurofibromata," and Durante "segmentary neuromata."

There has also been a considerable amount of recent work on nerve-cell tumours, "ganglio-neuroma," "neuroblastoma," and the like, both of the central and sympathetic nervous systems. And while the present series only contains four neuroblastomata, certain comparisons can be made between these and between them and other tumours of nervous origin, more favourably than when they are examined by ones and twos as is most usual in the literature.

A neuro-pathological laboratory has thus an advantage over that of a general hospital in the number of specimens of tumour of the brain which can be collected for an examination; but it has disadvantages in that tumours of other parts of the body are seldom met with, and in this way mesoblastic tumours occurring within the cranium may not be correlated well with those occurring in other parts of the body.

To avoid this I have asked the opinion of Professor Matthew Stewart, of Leeds, on the nature of several of the tumours, and I am greatly indebted to him for his help and interest.

I desire also to record my thanks to the medical and surgical staff of the National Hospital for their courtesy in allowing me to make use of their cases, and for the help and advice which they have always readily offered.

METHODS OF EXAMINATION.

A word must be said as to the methods adopted for examination. As all the tumours were fixed in 10 per cent. formalin immediately after removal from the body, it was found to be impossible to use many of the special staining methods for neuroglia and collagen fibres. As a routine, hæmatoxylin with van Gieson's counterstain was adopted as well as Heidenhain's iron-alum hæmatoxylin, which served to show up the character of the cell nuclei and processes. The latter stain was especially useful in the very cellular gliomata. All the neuroblastomata and certain of the acoustic nerve tumours were examined by Bielschowsky's silver method for paraffin blocks after pyridin. This was found to give very satisfactory results, but it was controlled whenever the consistency of the tissue permitted, by the method for frozen sections. Where Nissl and Weigert-Pal staining was done, other nervous tissues were put through at the same time as controls.

The photographs do not represent a complete series, but are only introduced to illustrate cases of special interest, or to serve as ocular demonstrations of unusual features.

TABLE.

No. of case	Initials of patient	Age in years	Nature of tumour	Figure	Duration of symptoms	
					Before admission	Before death
1	L. E.	22	Tuberculomata	—	8 months	11 months
2	L. S.	11	Tuberculoma	—	5 weeks	7 months
3	C. B.	13	Granuloma	—	27 months	—
4	J. L.	11	Sarcoma	—	3 months	9 months
5	W. V.	54	Fibrosarcoma	—	2 months	5 months
6	E. B.	?	Endothelioma	—	12 months	12 months
7	Mrs. M.	36	Endothelioma	—	2½ years	2½ years
8	Miss K.	?	Endothelioma	—	?	?
9	A. B.	35	Endothelioma	—	6 years	6 years
10	W. B.	31	Multiple endotheliomata ..	1-3	6 months	9 months
11	C. D. H. D.	?	Endothelioma	—	2 years	2 years
12	F. C.	62	Endothelioma	—	21 months	—
13	P. W.	43	Endothelioma	4	17 months	—
14	D. F.	11	Myxo-endothelioma ..	5 and 6	3 years	3 years
15	E. E.	13	Myxo-endothelioma ..	7	4 years	—
16	P. M.	48	Perivascular sarcoma ..	8	5 years	5 years
17	S. S.	9	Perivascular sarcoma ..	9 and 10	3 months	4 months
18	C. P.	46	Perivascular sarcoma (malignant)	11	15 months	16 months
19	W. P.	?	"Sarcomatosis of meninges"	12	4 months	6 months
20	A. B.	20	Glioma	13	3 months	3 months
21	W. W.	29	Glioma	14	2 months	4 months
22	A. M.	58	Glioma	—	2 years	2 years
23	T. C.	22	Glioma	—	4 months	4 months
24	Mrs. G.	52	Glioma	—	2 months	4 months
25	A. T.	43	Glioma	—	6 months	14 months
26	J. W.	49	Glioma	15	4 months	4 years
27	R. H.	16	Multiple gliomata	—	3 weeks	4 months
28	X. Y.	—	Glioma and "spongioblastoma"	16	—	—
29	L. R.	24	Glioma of pons	17	4½ months	11 months
30	L. C.	13	Multiple gliomata of nerve roots	18	2 months	3 months
31	W. H.	26	Neuroblastoma (malignant)	19 and 20	6 weeks	2½ months
32	T. H.	35	Neuroblastoma	21-23	6 years	6 years
33	Pte. E.	?	Neuroblastoma (malignant)	24-27	6 weeks	3 months
34	M. B.	26	Ganglioneuroma	28-33	2½ years	3½ years
35	N. R. S.	22	Multiple "neurofibromata"	34-38	6 months	7 months
36	G. M.	38	"Acoustic nerve tumour"..	39	9 months	9 months
37	E. M.	?	"Acoustic nerve tumour"..	—	9 months	12 months
38	S. E.	43	"Acoustic nerve tumour"..	—	2 years	2¼ years
39	W. M.	?	"Acoustic nerve tumour"..	—	?	?
40	H. P.	35	"Acoustic nerve tumour"..	40	2 years	2 years

Relative proportion, age incidence and rate of growth—A glance at the table will show the relative proportions of the various forms of tumours encountered in this series. If a percentage is calculated it is found that tuberculomata total 5 per cent. and sarcomata 5 per cent., while granuloma only accounts for one case or 2·5 per cent. This has obviously no relation to percentage of incidence, but is due to the low rate of mortality in the granulomata and tuberculomata, and to the fact that sarcomata are more usually met with in general than in neurological hospitals. At the same time it is probably true that primary sarcoma of the brain is a rare disease.

The group of endotheliomata includes ten cases or 25 per cent., and " perivascular sarcomata " three cases or 7·5 per cent., and there is one anomalous case of meningeal infiltration which is probably allied to the endotheliomata. *Thus mesoblastic intracranial tumours form* 40 *per cent. of the present series.*

Gliomata total eleven, of which three are multiple. There are three neuroblastomata of the brain, and one ganglio-neuroma growing at the base of the brain. Thus *glia and nerve-cell tumours form* 37·5 per cent., or approximately the same as mesoblastic tumours.

Lastly, there are *six cases of acoustic nerve tumours*, one of which was multiple, making 15 per cent. of the series. There is considerable evidence that these should be regarded as of epiblastic origin.

In any case if we compare in this series forms of tumour peculiar to the nervous system with those which may occur elsewhere in the body, we find that the former total twenty-one and the latter sixteen. We must remember that even for the cases admitted to the National Hospital during the time covered by the present series, this will not represent a true proportion, as all the tumours brought from the operating theatre to the laboratory were of mesoblastic type; so that the proportion of other tumours is probably slightly higher.

These figures may be compared with those of Tooth for the years 1902 to 1911 inclusive, where in a total of 258 tumours, whose nature was verified after operation or post mortem, 40·2 per cent. were gliomata, whereas endotheliomata and sarcomata together amounted to only 22·4 per cent. and fibromata and fibro-gliomata 10·8 per cent. (these last all occurred in the posterior fossa of the skull, and all except four are noted as extra-cerebellar, so that we are safe in assuming that at any rate 10 per cent. are acoustic nerve tumours.

In Cushing's recently published monograph, his verified acoustic nerve tumours amounted to 8·8 per cent. of a series of 340 verified tumours, excluding tumours of the pituitary gland, of which, owing to his special work on them, he had a much higher proportion than the average.

While generalizations from such a limited number of cases are unjustifiable, it is worth while noting the *age incidence and duration* of symptoms of the various forms of tumours.

Both cases of *tuberculoma* were in young subjects, aged 11 and 22 respectively, and gave a fairly short history.

The *sarcomata* occurred, one at the age of 11, and one at the comparatively advanced age of 54. In these the history was a matter of a few months.

All the cases of *endothelioma* occurred after the third decade, except the two cases of myxo-endothelioma which occurred in children of 11 and 13 respectively. The latter tumours are very closely allied to the "mixed tumours of the parotid," and resemble them also in their age incidence. In them the symptoms dated from three and four years before admission to hospital. The other endotheliomata gave histories dating back at longest to six years, and at shortest to six months (this in a case of multiple tumours of the cerebellum).

In the *perivascular sarcomata* we are dealing with more malignant tumours, but in one case the symptoms dated to probably five and certainly three years before admission. In the shortest history of the three the tumour was in the centre of the cerebellum, where it caused hydrocephalus and thus hastened the fatal termination.

These tumours thus seem to be definitely more slow-growing than the sarcomata of the dura mater, in spite of their definite malignant tendencies.

The *gliomata* of the series all gave a very short history, amounting in only one case to two years, and in the others to six months at most before admission. One case of undoubted neuroblastoma also gave a very short history, whereas another gave a history of fits dating definitely to six years before he entered hospital.

The *tumours of the acoustic nerve* were true to type in having histories of moderate length; the shortest (six months) was in a case of multiple tumours; the longest was two years.

They are obviously fairly slow-growing tumours, but their position and relations enable them to be diagnosed early, and unless relieved by operation their site quickly makes them dangerous to life.

Discussion on the Nomenclature and Classification of Intracranial Tumours.

The present investigation was stimulated largely by the anomalies of nomenclature which have appeared and still appear in the literature of the subject. The objection to most of the names used is their reference to two forms of tissue which arise from different embryonic layers, e.g., mesoblast and epiblast. I refer to terms such as "glio-sarcoma," "fibroglioma," and "neurofibroma," which are used in such a way as to suggest that both the tissues named are essential elements in the structure of the tumour. These terms have been associated with the names of distinguished authorities, and it is therefore difficult to discard them without a full inquiry both into the reason for their adoption and the objections to their continued use.

The term "gliosarcoma" is justified by Lubarsch, who suggests that "the chief word must be determined by the morphological structure; if we can with certainty give the genesis, then indicate that by an adjective, as, for example, "endothelial adenoma," "epithelial adenoma," &c. This method of nomenclature is supported by Adami, who advises that the term "sarcoma" should be used "in a purely histological sense."

Bruns objects to the too frequent use of the term, which he considers due to the difficulty in diagnosis between glioma and sarcoma of the brain—"a reason why we often find the diagnosis 'glio-sarcoma' in the literature, either as an escape from a difficult diagnosis, or due to defective examination, as 'glio-sarcomata' *are probably very rare.*" (It is difficult to understand what is meant by the last phrase in the light of his previous remarks, and it is probably introduced in deference to contemporary opinion.)

Verocay and others have used the term "sarcomatodes" to indicate a histological picture resembling sarcoma, and the general use of the term "glioma-sarcomatodes" would give rise to much less confusion than the name "glio-sarcoma."

The term "neuro-fibroma" is countenanced by such long use that it will probably survive, at least until the histogenesis of this type of tumours is set on a more satisfactory basis. But it must be remembered that von Recklinghausen, in his second paper on the subject, withdrew the term "neurofibroma" as unjustifiable; and called the tumours simply "multiple fibromata." There seems to be no precedent or analogy to justify the name "neuro-fibromata" in the sense of fibromata growing in nerves; for according to von Recklinghausen's theory of origin the tumours originate from the endoneurium, and cause more destruction than overgrowth of the purely nervous elements. On the other hand it is generally conceded that "neuro-fibromata" differ in histological appearances from all other fibromata, keeping to a type of their own.

The name "fibro-glioma" or "glio-fibroma" is in common use as describing tumours of the acoustic nerve. And the way in which the terms are used suggests that the writer is describing the appearances rather than attempting to define the origin of the tumour. The picture suggested is that of a tumour, parts of which are fibrous (though not necessarily formed of connective tissue fibres), while other parts resemble glial tissue. There are several analogies for the term "fibro-glioma," as meaning a glioma in which there is overgrowth of fibrous tissue, either to replace degenerated areas of the tumour, or formed as a reaction on the part of the connective tissue elements to the irritation of the tumour growth. And there is no doubt that some tumours of the acoustic nerve show such fibrous tissue increase. But it must be admitted that such is not the meaning intended by most writers on the subject; nor is it a correct description of the histological appearances of most of these tumours.

The objection to all these terms is that they convey the suggestion, whether intentionally or not, that the tumours arise from some cells of mesoblastic and others of epiblastic origin. And while it is allowed that this occurs in the teratomata, it is most unlikely that either glio-sarcomata or fibro-gliomata are teratomatous. In some cases, especially in the "neuro-fibromata" and the "fibro-gliomata," there is no definite knowledge as to the embryonic layer from which the tumours take their origin, and therefore they have been named "in a purely histological sense." But the confusion to which this method of naming tumours gives rise is evident from the multiplicity of names which have been applied to acoustic nerve tumours, in spite of the very constant histological picture which they present.

The truth of Cohnheim's "cell-rest" theory is assumed here, in so far as it holds that a tumour arises from a cell or group of cells which has been isolated at some stage of development and has remained immature and functionless. Their lack of function may lead the cells to assume tumour growth (Adami), or there may be a diminution of the resistance of the surrounding tissues to such growth (Ribbert). Probably both factors are at work. Ribbert's theory is upheld in part by the occurrence of multiple primary tumours, either of the same or different types (see Cases 30 and 35), which suggests that at some period of growth, most usually during either adolescence or senescence, numerous "cell rests" commence active tumour formation.

It is evident from an examination of the cases in this series that one of the commonest seats for such "cell rests" is the junction of the nerve roots with the brain stem and cord—the so-called "transition zone."

It is possible that all stages in the development of a mature nerve cell or glia cell from the cells lining the neural crest may be represented in "cell rests." And the suggestion is put forward that certain of the neuroblastomata arise from cells which have not reached the stage of differentiation into "spongioblast" and "neuroblast," and can thus give rise to cells both of the glia cell and nerve cell types. In a similar may, according to Verocay, tumours of the acoustic nerve may contain ganglion cells, as well as immature glia cells and sheath cells.

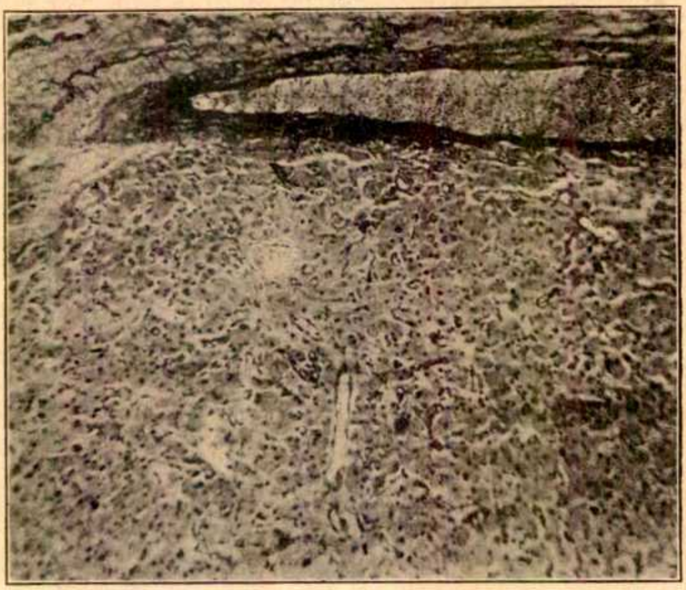

FIG. 1.—Case 13. P. W. Endothelioma of dura. The capsule contains a large vein. The tumour is formed of larger cells less clearly separated from one another than in fig. 4.

It is more difficult to understand why "multiple central neurofibromata" should be so frequently associated with endotheliomata or psammomata (see Case 35 and Verocay), if we consider the latter tumours to be of mesoblastic origin. This might be accounted for by the theory of "diminished external resistance," and there are many analogous cases of tumours of various types arising at the same time in different organs. But when psammomata and endotheliomata are met with so frequently in conjunction with multiple "neurofibromata," the suggestion cannot be far from our minds that the association is more than accidental, and that they may not be very dissimilar in origin. Either neurofibromata may be endothelial tumours (which seems unlikely), or psammomata may be derived from "sheath cells," as is not altogether improbable (see Case 35).

Endotheliomata.

The common forms of endothelioma present little difficulty. There appears to be a distinct difference both in the macroscopic and microscopic appearances between endotheliomata of the dura and of the pia-arachnoid.

The dural form is smoother, usually covered over by a glistening membrane, and is composed of cells of a rounded or oval shape, with, in some cases, incomplete division between the cells (see fig. 1).

The arachnoid form (which need not necessarily appear on the surface, and is often embedded in the brain so that only a small area presents) is rougher and is covered by a fine network of arachnoid membrane. On cut section it is more granular, and histologically it is more fibrous, being usually composed of elongated cells in whorls, with very numerous capillary blood spaces (see figs. 1, 2 and 3).

The following is a case of multiple endotheliomata of the cerebellum :—

Case 10.—W. B., aged 31 (physician, Dr. Batten): *Multiple endotheliomata.* Admitted March 20, 1918. Died June 12, 1918.

History.—Patient became giddy while on parade in October, 1917, but he had no headache or vomiting; he became worse and had a tendency to fall to the right. After admission he had occasional headaches, and attacks of vomiting, his voice was staccato, and he had general bodily weakness, but no sensory loss.

(An elder brother and younger sister died "of the same thing." Mother, aged 71, alive and well, three brothers well.)

Macroscopic Appearances.—On removal of the brain a yellowish softened area was seen on the posterior surface of the left cerebellar hemisphere. When hemisection was made between the two cerebellar hemispheres, an irregularly shaped cavity was seen lined with a thick yellow membrane which was easily tumours to be of mesoblastic origin. This might be accounted for by the theory of "diminished external resistance," and there are many analogous cases of tumours of various types arising at the same time in different organs. But when psammomata and endotheliomata are met with so frequently in conjunction with multiple "neurofibromata," the suggestion cannot be far from our minds that the association is more than accidental, and that they may not be very dissimilar in origin. Either neurofibromata may be endothelial tumours (which seems unlikely), or psammomata may be derived from "sheath cells," as is not altogether improbable (see Case 35).

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Macroscopic Appearances.—On removal of the brain a yellowish softened area was seen on the posterior surface of the left cerebellar hemisphere. When hemisection was made between the two cerebellar hemispheres, an irregularly shaped cavity was seen lined with a thick yellow membrane which was easily wards and outwards into the upper part of the right cerebellar hemisphere, where it is very irregular. There are four openings towards the middle line and many divarications in the substance of the cerebellum. It extends antero-posteriorly for 5 cm., and laterally for 3·5 cm.

In addition to this two tumours were found: the larger one in the left cerebellar hemisphere 1 cm. from the middle line; it is a small round tumour, clearly defined and surrounded on the upper surface by a smooth-walled cyst measuring 3 mm. in the vertical line, and 12 mm. antero-posteriorly. The cyst wall is apparently formed of smooth, slightly reddened brain tissue. The tumour itself is rounded, rather granular on the surface, and about 10 mm. in diameter.

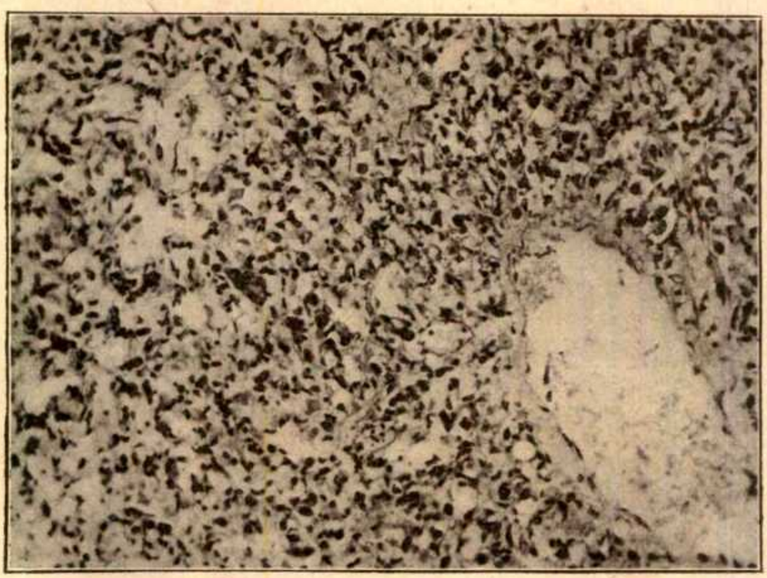

FIG. 4.—Case 10. W. B., Multiple endotheliomata. Section of tumour figured in fig. 3. Note the very numerous small blood channels. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

A similar, much smaller tumour is apparent on the right hemisphere, near the postero-inferior surface, running almost to the surface and about 1 cm. from the middle line. It measures 3 mm. in diameter. There is also a similar small rounded tumour in the left cerebellar hemisphere, attached to the cyst wall.

There are some small hæmorrhages into the pons; otherwise, except for some flattening of the sulci, the brain shows no abnormality.

Microscopically.—The tumour is composed of rounded collections of large epithelioid cells separated by strands of connective tissue. The cells in the masses have no very definite arrangement in whorls. They are large cells with palely staining nuclei and abundant cytoplasm; often two or three cells are joined together, forming a kind of syncytium. In other parts of the tumour

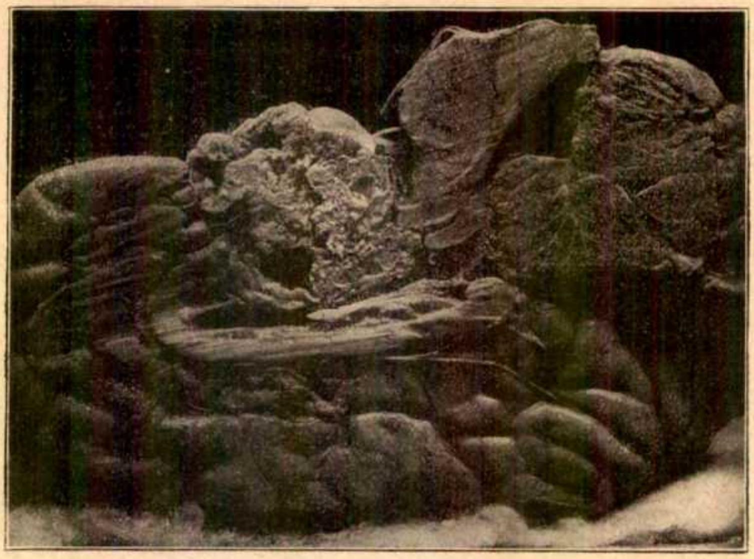

FIG. 5.—Case 14. D. F. Myxo-endothelioma.

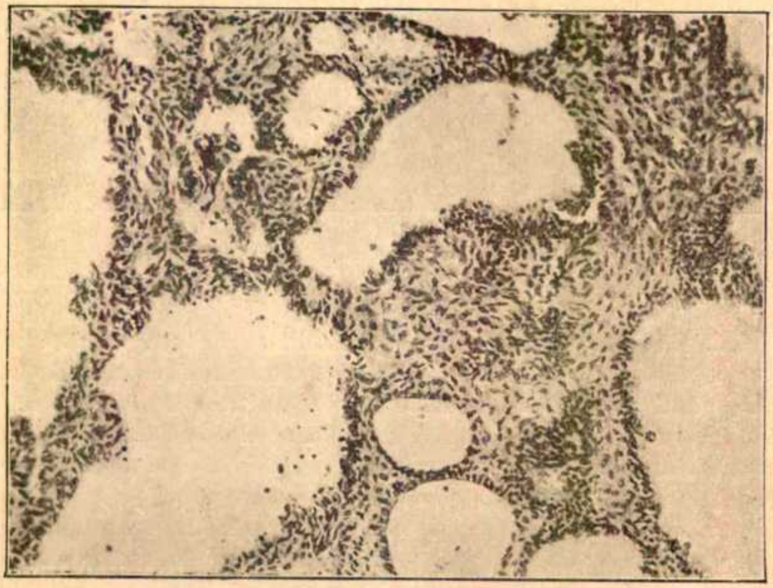

FIG. 6.—Case 14. D. F. Myxo-endothelioma. General view of tumour structure. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

there is some tendency for fibrous tissue and fibrous processes to separate the individual cells.

In parts the tumour is very vascular, and capillary vessels are formed between the cells. Large vessels composed of a definite endothelial lining and fibrous tissue walls are very numerous. In some places there are groups of ten or more large vessels separated only by one or two layers of endothelial cells, or merely by the fibrous processes of these, and in some places there is considerable œdema surrounding the vessels.

The cyst wall appears microscopically to be poorly defined from the brain tissue, and its structure is very degenerate; many cells take practically no nuclear stain, and others contain blood pigment. The remainder of the substance is formed of cells of all shapes and sizes and thick fibrous bands. Everywhere the nuclei are pyknotic, and there is much granular debris. The appearance suggests that the cyst wall is formed from tumour tissue, rather than cerebellar tissue.

This is a somewhat unusual form of endothelioma, and quite unlike any other in the series. The appearances suggest a tendency to malignancy, and the apparent breaking down of the largest tumour, with the formation of small tumours elsewhere in the cerebellum, supports this view. The great vascular proliferation is also unusual. In all probability the seat of origin of the tumour was in the pia mater running between the lobules of the cerebellum (see figs. 1, 2 and 3).

Cylindroma.

This name has been used by the German writers to describe a definite slow-growing form of tumour. They are usually met with in young subjects, most often in relation to the salivary glands, but they may occur elsewhere, and a considerable number of intracranial "cylindromata" have been described. Here we are dealing with a tumour which arises from a multipotential cell, which may be a germ cell (i.e., the tumour being a teratoma) or an undifferentiated mesoblastic cell (i.e., the tumour being a "terato-blastoma").

It is unnecessary to enter here into the discussion between these two theories of origin. In the present series these tumours have been provisionally labelled "myxo-endotheliomata," as the English school seems to favour their mesoblastic origin, and has not accepted the term "cylindroma" at all generally.

They consist of areas of myxomatous tissue surrounded and divided by bands of elongated cells covered with one or more layers of epithelioid cells which may be columnar or cubical in shape. In some of these tumours there are knots of cartilage, or of tissue which resembles cartilage but has not the consistency of fully formed cartilage.

The resemblance of the epithelioid cells to what is seen in some of the endotheliomata is sufficiently close to justify the inclusion of these mixed cell tumours in the mesoblastic group.

Both the cases in the present series were young children of 11 and 13 years, and in both the symptoms had lasted for some years. In one case the tumour was at the base of the brain, and may have had some relation with the base of the skull, but in the other, where the growth was removed at operation, it was near the vertex of the cerebrum and appeared to have no connexion with the base. In both cases the tumour appeared to be a primary growth (see figs. 5, 6 and 7).

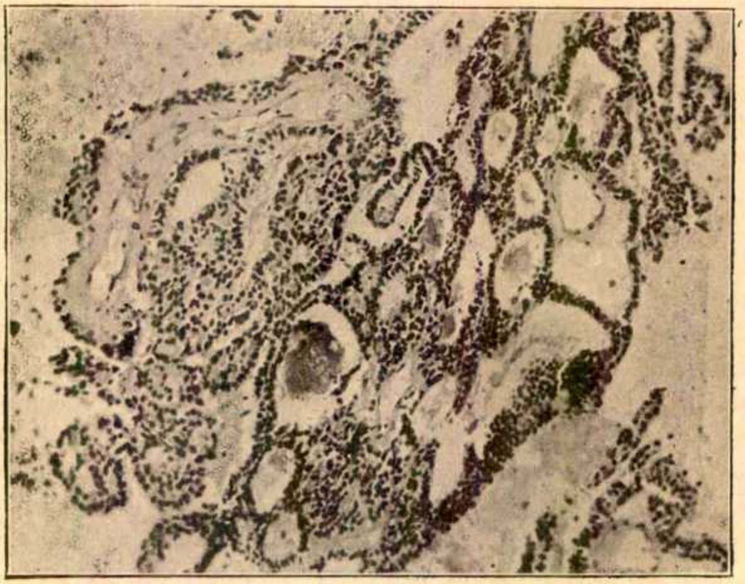

FIG. 7.—Case 15. E. E. Myxo-endothelioma. General view of tumour structure. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

"*Perivascular Sarcoma.*"

Macroscopically, it is a very difficult matter to distinguish endotheliomata from "perivascular sarcomata," but a careful examination of the surface of the tumour, as it shows on the cortex of the brain, may reveal, in the latter form, fine ridges which give exactly the appearance of a tightly packed bundle of fine white wool; whereas in the endotheliomata the surface is more granular. The line of separation from the brain substance is very different; the endotheliomata peel out, leaving the brain tissue covered with a fine arachnoid layer, and are themselves covered with a similar layer; whereas the "perivascular sarcomata" are more intimately united with the brain substance, and bring away a small amount of brain matter attached to them.

The term "perivascular sarcoma" has been used provisionally for three tumours of this series. Their slow rate of growth, the macroscopic appearances of a rounded, granular or "woolly" tumour growing outwards from a central core, and the histological characteristics, especially with regard to the proliferative activity of the cells of the vessel walls, distinguish them from other sarcomata. It is not necessary to enter here into the controversy as to whether the tumour cells take origin from the adventitial endothelium, but there can be little doubt that the blood-vessels do play more than a subordinate part in their structure. It is to be noted that the classic type of "perithelioma" of von Hleb-Koszanska, occurring in the sacro-coccygeal region, has been called in question by Alezais and Peyron, who consider that the so-called "peritheliomata" of this region are in reality nerve-cell tumours, developed from remnants of the neural epithelium. It can be seen in the succeeding notes and illustrations how close the histological resemblances are between tumours classed as "perivascular sarcomata" and the "neuroblastomata."

The diagnosis of "perivascular sarcomata" from other forms of sarcomata lies in the appearances of the vessels, where the walls, formed of several layers of endothelial cells, seem to be everywhere budding out to form new vessels. In the older and more central parts of the growth the vessels are surrounded by several layers of fibrous tissue, and in places this has become hyaline; but towards the edges of the tumour and in the more rapidly growing forms this proliferative activity in the cells of the vessel walls is very well seen. In some of the tumours the cell multiplication is obviously rapid, and many irregular mitotic figures are seen in a dense cell mass. In others, the more characteristic arrangement of columns of cells surrounding in a irregularly radial manner a fairly thick-walled blood-vessel, suggests a slower growth, and the deficient vascularity is shown by the cell degeneration which takes place at a definite distance from the central blood-vessel.

Their relatively slow rate of growth is proved by one case in which five years elapsed between the onset of symptoms and death, whereas in the case which showed most histological evidence of malignancy symptoms appeared sixteen months before death. In all three cases the tumour was found in the substance of the brain, and in only one case did

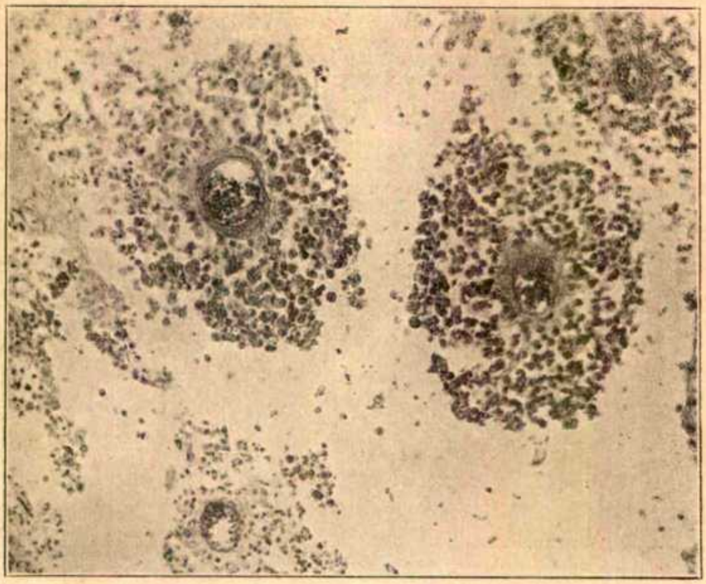

FIG. 8.—Case 16. P. M. "Perivascular sarcoma." The degenerated areas round columns of cells have fallen out of the section. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

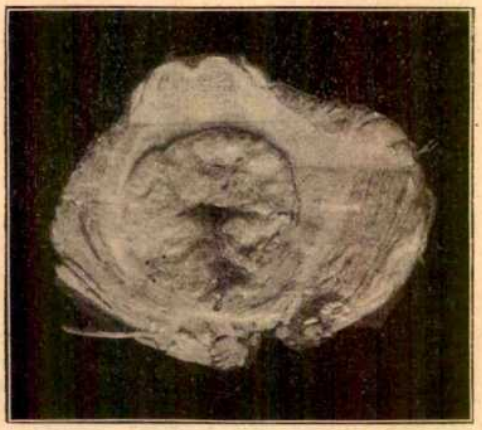

FIG. 9.—Case 17. S. S. "Perivascular sarcoma." Central tumour of cerebellum.

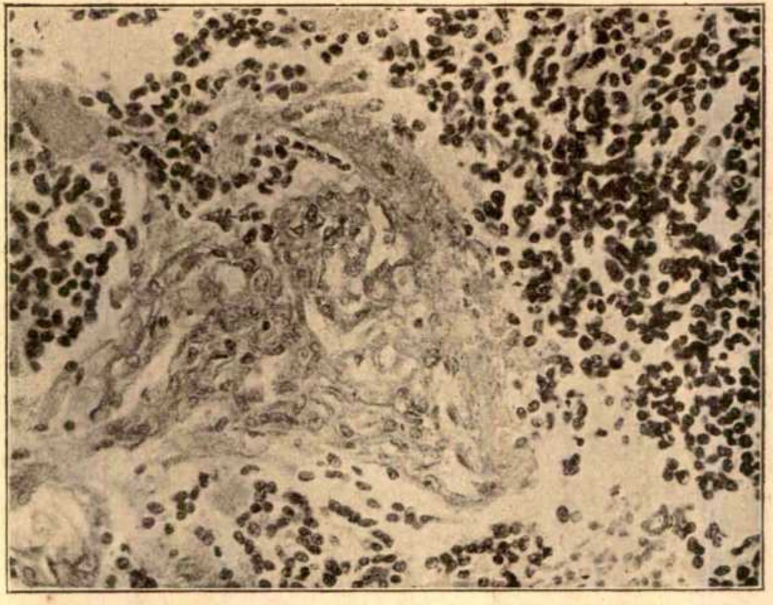

FIG. 10. Case 17. S. S. "Perivascular sarcoma." High-power view of small vessel. (Hæm. v. Gieson. Zeiss 8 mm. obj.)

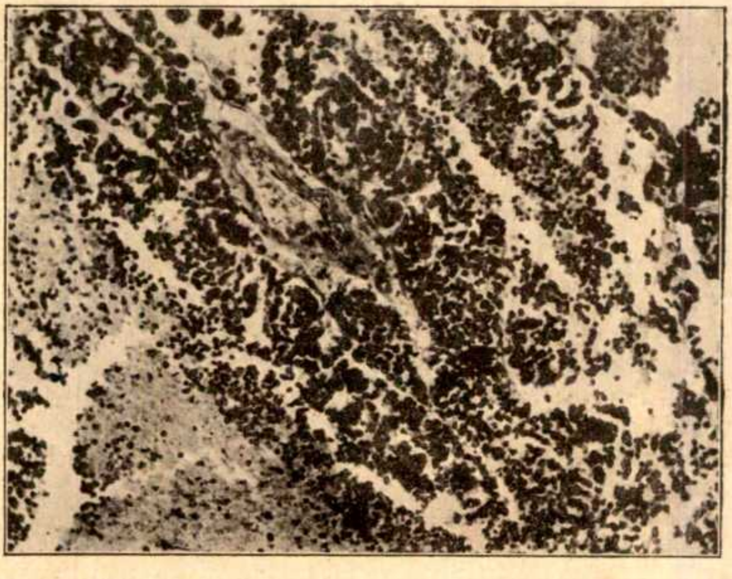

FIG. 11.—Case 18. C. P. "Perivascular sarcoma." Perivascular arrangement of cells with peripheral degeneration. Note cellular thickening of vessel walls. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

the tumour appear on the surface. In two, cystic spaces were formed in the tumour, whereas in the third a depressed area of softening was seen on section.

It may be that later work will class many forms of this type of tumour under tumours of nervous origin. They undoubtedly show much in common with the neuroblastomata, and with certain tumours (e.g., Case 30) which have been classed in the past either as sarcomata or gliomata (see figs. 8 to 11).

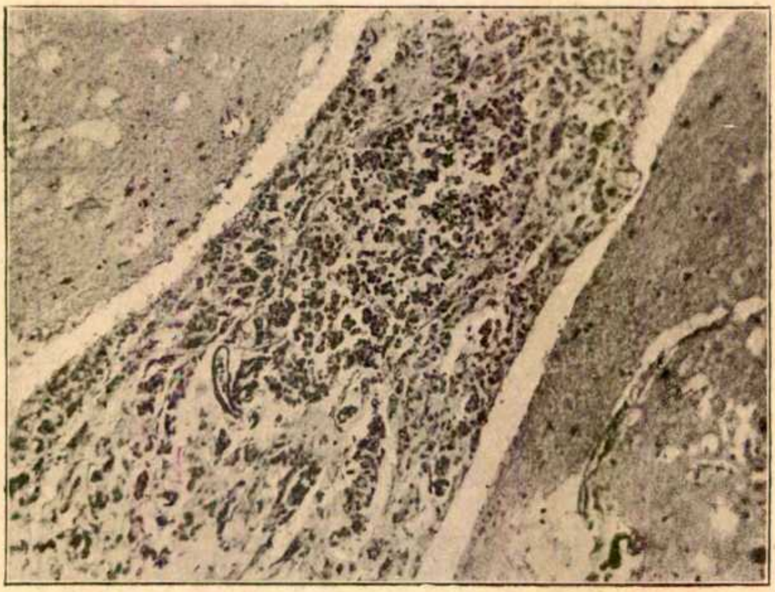

FIG. 12.—Case 19. W. P. "Sarcomatosis of meninges." Sulcus on cortex of brain, showing infiltration of arachnoid with epithelioid cells. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

The following anomalous case has provisionally been classed as "*sarcomatosis of meninges*."

Case 19.—W. P. (physician, Dr. Wilson). Admitted May 1, 1916; died July 3, 1916.

History.—Headaches began in January, 1916, along with an attack of vomiting and followed by occasional loss of power in the right leg. A decompression operation was performed after admission on the left side of the skull, but no tumour was found.

Macroscopic appearances.—There is a large hernia on the left side of the brain, a considerable degree of hydrocephalus was present, and there was a definite thickening of the membranes round the fourth ventricle. The pia mater was thickened in the sulci and to a less extent over the convolutions, and round the pons and the cisterna magna it is greatly thickened up to 2 mm.

On section of the brain the ependyma appears thickened and strips off as a membrane about 1·5 mm. thick. (This is partly due to faulty preservation.)

Microscopically, the meshes of the arachnoid, both over the base of brain and the sulci of the cortex, are densely packed with small rounded cells. These have a granular cytoplasm and a rounded nucleus, which is usually placed somewhat eccentrically. The cells tend to group themselves into irregular bunches or columns, and are more closely packed in some places than in others. They fill up the adventitial lymph spaces of the blood-vessels in the arachnoid. They are separated from the cortex of the brain by pia mater, through which they show no tendency to pass. Blood-vessels running in from the pia mater, however, in many places contain numerous cells in their adventitial sheaths, and the vessels which run into the optic thalamus from the base of the brain are surrounded by a thick sheath of similar cells. The optic nerves are also surrounded by a sheath of cells of similar character.

The hydrocephalus is apparently due to blockage of the foramina of Majendie and Luschka, and the general damming back of the subarachnoid circulation.

The nature of the cells which fill the spaces of the arachnoid is by no means clear. At first sight their close resemblance to the cells lining the ventricles suggested that they might be of the nature of a desquamation of the ependymal cells. But there is no evidence of disease or desquamation of this membrane. On the other hand, the arrangement of the cells in the meshes of the arachnoid suggested some more definite tumour formation. The "acinous" arrangement may be purely due to the meshes of the arachnoid membrane, but it does suggest that the cells are actually multiplying in these meshes. And it is doubtful whether such a widespread and regular involvement of the membranes all over the cortex as well as the base could possibly occur purely as a result of the carriage of cells by the cerebrospinal fluid. A possible explanation is that the cells filling the arachnoid arise as a neoplastic overgrowth of the endothelial cells lining the arachnoid meshes, and that this is a form of endothelioma.

It seems likely that cases of this kind have previously been described under the heading of "Sarcomatosis of the Meninges" (see fig. 12).

TUMOURS OF NERVOUS TISSUE.

With regard to the typical gliomata little need be said. Their diagnosis rests as much with the macroscopic as with the microscopic appearances. For, as Bruns points out, a greyish gelatinous tumour infiltrating the brain substance, but causing little alteration of its appearance, is almost certainly a glioma. There may be smaller or larger areas of hæmorrhage or softening with the formation of cysts, and at times it may be difficult to distinguish such appearances from those of purely vascular disease. In such cases the history may be a help, but the

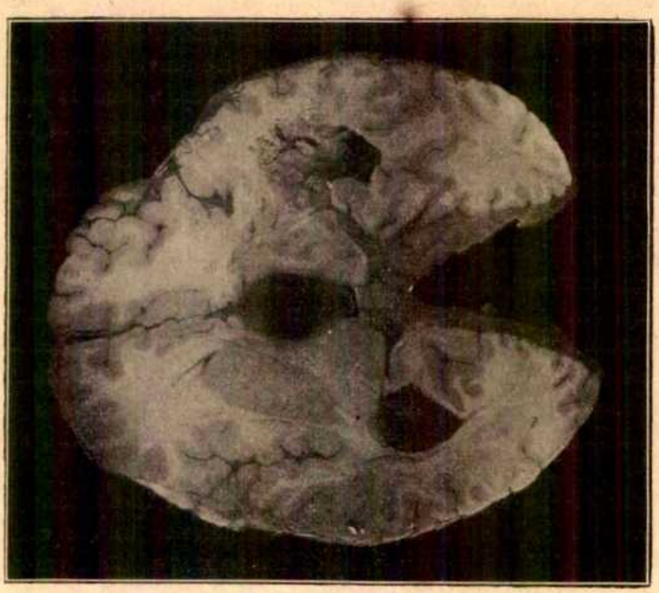

FIG. 13.—Case 20. A. B. Glioma. Hæmorrhagic glioma filling up third ventricle, causing hydrocephalus of lateral ventricles.

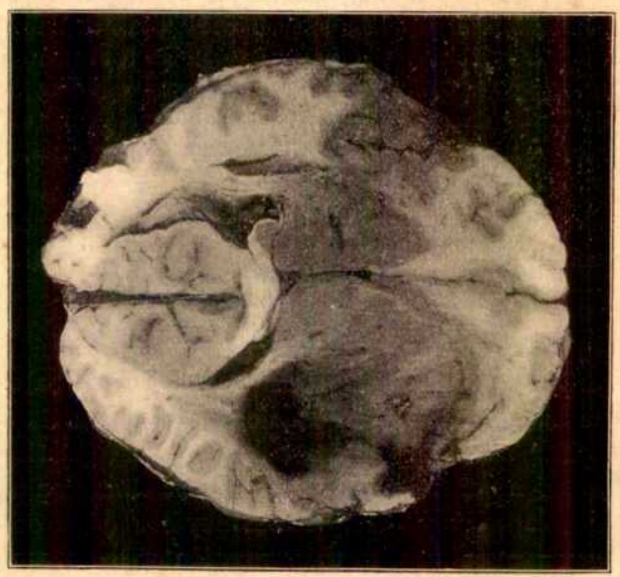

FIG. 14.—Case 21. W. W. Glioma. Softening in gliomatous area of right centrum ovale communicating with the surface by a narrow channel, and simulating a wound of the brain.

diagnosis rests in the end with the microscope. Such difficulties were presented by Cases 20 and 21, where on clinical grounds the diagnosis of tumour was made, but the macroscopic appearances threw doubt on this, until the diagnosis was confirmed by examination of microscopic sections (see figs. 13 and 14).

In many cases where the undifferentiated character of the tumour cells causes a diagnosis of sarcoma to be made, it may be noted that the blood-vessels have a thicker endothelial lining than is usually seen in "small round-celled sarcomata," and that the cells are not in reality round cells, but are stellate, their angles being prolonged into fine processes which can be traced for some distance. A confirmation of the diagnosis may sometimes be obtained from the fact that, when multiple, the growths remain limited to the nervous system (see Case 30).

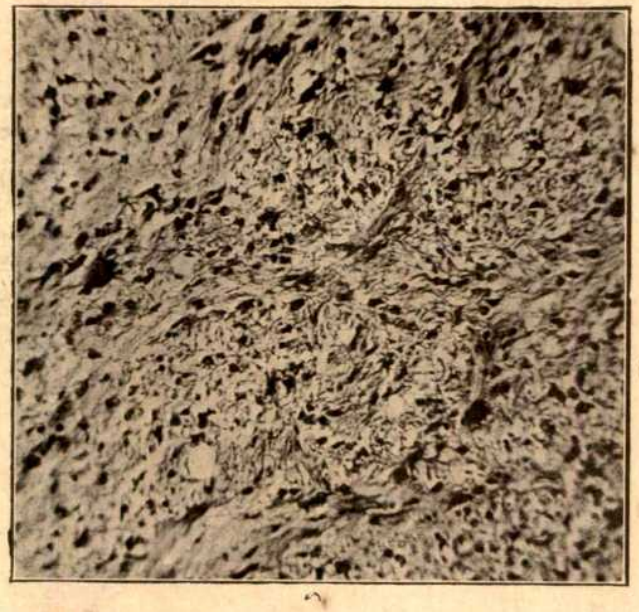

FIG. 15.—Case 26. T. W. Glioma. A glioma of a rather fibrous type. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

For the most part the cells of a glioma resemble the "spider" cells of tissue reaction in the central nervous system, but tend to have a more clearly defined ring of cytoplasm than the mature spider cell. In some tumours they are elongated and resemble fibroblasts, but sections stained with iron-alum hæmotoxylin show that the terminal processes are not single fibres, but break up immediately on leaving the cell diagnosis rests in the end with the microscope. Such difficulties were presented by Cases 20 and 21, where on clinical grounds the diagnosis of tumour was made, but the macroscopic appearances threw doubt on this, until the diagnosis was confirmed by examination of microscopic sections (see figs. 13 and 14).

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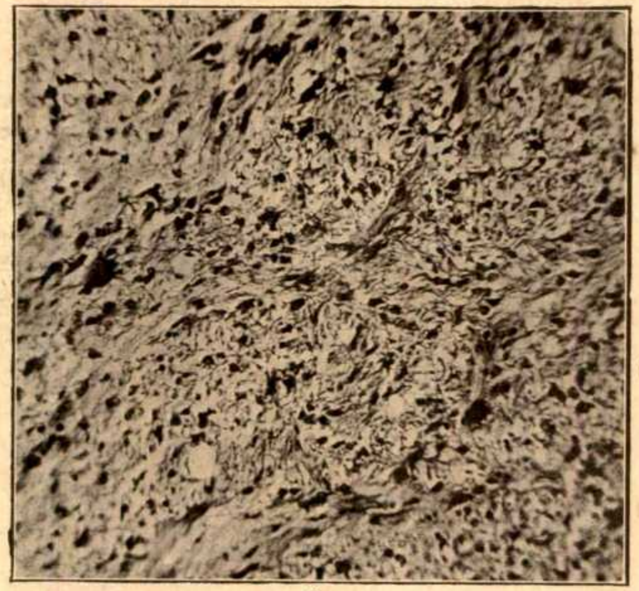

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Areas of "spongioblasts" occur in many tumours of nervous origin which resemble gliomata or neuroblastomata in their general characteristics. And their similarity in appearance and probably in origin also to the rosettes seen in gliomata of the retina has already been noted. It is suggested that the term "spongioblastoma" should not be applied to such tumours, but reserved for tumours where the whole structure, as in the present instance, or the majority of the tissue, consists of columns of spongioblastic cells. The presence of spongioblasts suggests that the tumour arises from some "cell rest" which was isolated at an early stage of development when glia cells had just begun to be differentiated from spongioblastic cells, and the resulting tumour tends to reproduce both types of cell.

Case 28.—X. Y. (Dr. Batten).

Microscopic appearances of the small, round subependymal tumour, lying close to the left lateral ventricle. The characteristic portions of this tumour show rounded or irregular columns, composed of an outer zone of nuclei in several layers, and a core which resembles the ground substance of brain tissue, staining brownish with van Gieson's stain. Some of these columns are cut transversely, others more longitudinally, but they are obviously very irregular in shape and branch in all directions. In some of them there is a number of cells lying in the core, but, on the whole, it is devoid of nuclei. In sections stained with iron-alum hæmatoxylin, the cells forming the outer zone are seen to be mainly elongated cells, with a long process running into the core and merging insensibly with the processes of other similar cells, and at the outer end one or more short processes, finer and less easily traced, which seem to blend with processes of the cells which lie between these columns. In addition, there are in this zone a number of binuclear and polynuclear cells of rather more rounded outline and less definite processes. In between the columns the tissue is very cellular, the cells being of very varying size and shape, mainly with a single rounded or oval nucleus and ill-defined processes, but many very large polynuclear cells are also seen, some with a ring of nuclei at the periphery and a clear centre, others with the nuclei more centrally placed. These cells are more globular in shape than the mononuclear cells, but have several short processes which join with the processes of surrounding cells.

The blood-vessels run in the tissue between the columns, and are nowhere seen in their substance. They are composed of a single layer of fibrous tissue and an endothelial lining.

The tumour is obviously of the glial type, the cells which lie between the columns being exactly those seen in a typical glioma, and the cells forming

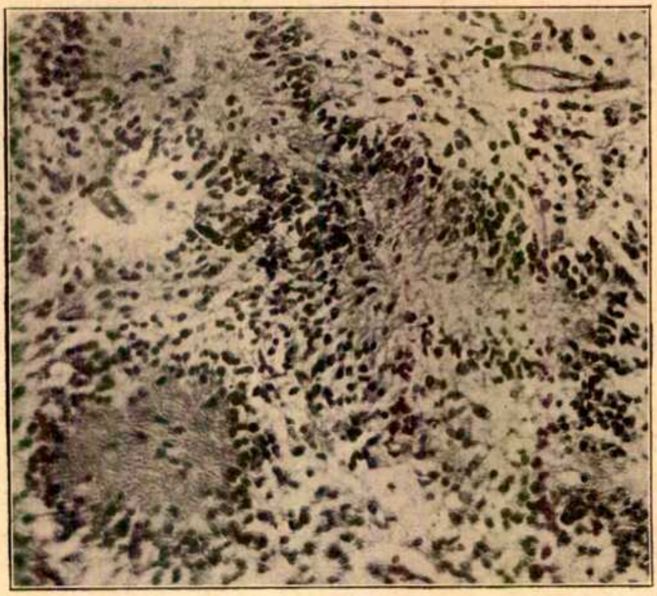

FIG. 16.—Case 28. X. Y. "Spongioblastoma." Spongioblast tumour. Note that the vessels run in glial stroma outside the columns of spongioblast cells. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

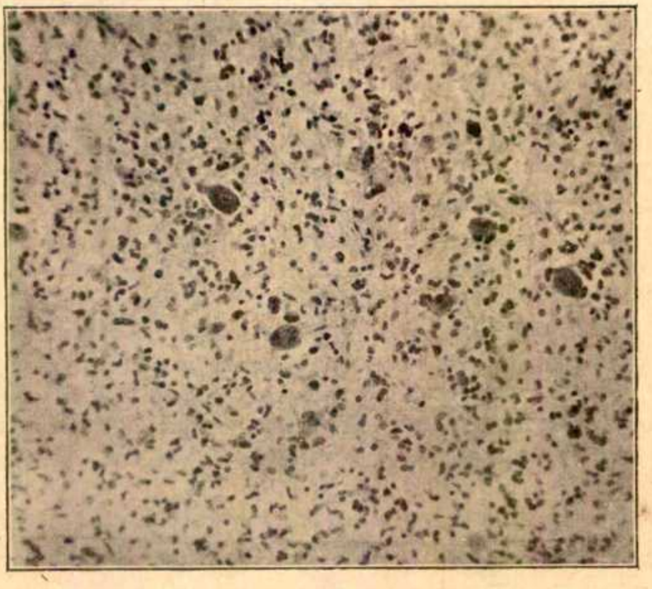

FIG. 17.—Case 29. L. R. Glioma pontis. The nerve-cells in the infiltrated area are undergoing degenerative changes, but one is practically normal. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

the columns being similar to the ependymal cells surrounding the central canal, with the difference that the longer process runs inwards instead of outwards as it does in the central canal.

Except for the fact that the ventricular ependyma is seen to run over the tumour with very little alteration, it might have been supposed that the tumour was formed by villous protrusions of the ependyma (so to speak); although in that case the blood-vessels and gliomatous tissue would have been inside and not around the columns.

Both the situation and the nature of the tumour suggest that it is a neoplasm of the ependymal cells, a so-called "spongioblastoma" (see fig. 16).

Case 29 presents a very typical example of the condition which used to be described as "hypertrophy of the pons."

Case 29.—L. R., aged 24 (physicians, Drs. Hinds Howell and Saunders). Admitted January 7, 1918. Died August 6, 1918.

History.—Patient was flying on August 18, 1917, and was obliged to make a "forced landing," falling twenty feet. He was unconscious after this for one and a half hours. He recovered sufficiently to go on duty again that day, but two days later his right ankle "did not go right"; on the third day he had a bad attack of "colic," and could not speak or chew properly. He became progressively worse; on admission he had right hemiplegia.

Macroscopic examination.—The chief obvious abnormality of the brain, as seen from the base, is enormous enlargement of the pons, chiefly of the left side. A horn-like outgrowth is seen near the upper border of the left side of the pons, and a similar but smaller growth on the right side.

On section, except for the enlargement, very little abnormality is seen, the transverse striations being well marked, but there is a small area of softening about the centre of the pons under the floor of the fourth ventricle.

The enlargement extends from the pons up into the mid-brain and crura cerebri, and downwards into the medulla.

The transverse diameter at the upper end of the pons is 6·5 cm.: anteroposteriorly the greatest width at this level is 5 cm.; the length of the pons, from mid-brain to medulla, is 3·5 cm. At its junction with the cerebrum the mid-brain measures 4 cm. in transverse diameter, and 4·5 cm. in anteroposterior diameter.

Microscopic examination.—Sections of the pons show a fairly loose texture of glial cells of all kinds, most of them with well-defined processes, corresponding to the elongated spider cells of glial reaction. Many are multinucleated, some globular and of large size, and cells with rings of nuclei around their periphery are fairly common. The nerve-cells in the area infiltrated by the tumour show some degeneration, the bodies being more globular than normal, the nuclei rather hyaline, and in some cases eccentric, and the cytoplasm containing large numbers of brownish granules. No "neuronophagy" is seen, however. (See fig. 17.)

The blood-vessels are numerous and well formed, even the smallest having a definite ring of endothelial cells. Some show considerable proliferation of the cells of their adventitial coats, as well as infiltration of the adventitial lymphatics. The latter is especially seen around the area of softening under the floor of the fourth ventricle. In the actual area of softening, only the outline of the vessels and cells can be seen, with no nuclear staining. The blood-vessels in the immediate vicinity are all distended, and their adventitial spaces packed with cells.

Multiple Gliomata of the Nerve-roots.

This rare condition is illustrated by the following case:—

Case 30.—L. S. (Dr. Collier), aged 13. Admitted April 11, 1918. Died, May 26, 1918.

History.—Vomitings commenced two months before admission, followed a fortnight later by headaches, and a burning pain over his eyes. He also had diplopia, and pain in the legs. On April 24, 1918, a subtentorial decompression operation was performed, but no tumour was found.

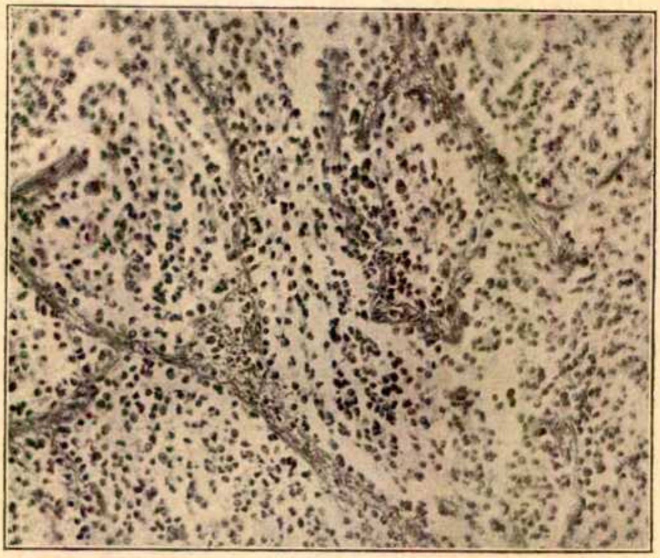

FIG. 18.—Case 30. L. C. "Multiple gliomata of nerve-roots." General view showing arrangement of cells along the walls of vessels. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

Macroscopic appearances.—At the post-mortem examination a number of small tumours were found, as follows:—

(1) There is a fleshy, flattened tumour replacing the left olfactory bulb, and slightly adherent to the membranes covering the cribriform plate.

(2) Between the crura cerebri, filling up the sulcus oculomotorius, is a round tumour mass about 1 cm. in diameter, reaching up to within 2 mm. of the floor of the third ventricle.

(3) At the centre of the pons there is a large mass which fills up the ponto-cerebellar angle on both sides. It is larger on the left side than the right, and in size and shape is like a broad bean.

(4) On the left side of the upper part of the medulla is a large mass, pressing inwards from the groove between the medulla and cerebellum to 3 mm. from the middle line, and measuring 15 mm. transversely and 10 mm. antero-posteriorly.

(5) There is a very small tumour at the same site on the opposite side 3 mm. in diameter.

The cord is covered both anteriorly and posteriorly with fleshy sessile growths, varying in size. At the mid-dorsal level (seventh dorsal) they compress the cord on either side so that it is narrowed to the width of 4 mm. There is scarcely a nerve-root which has not one of these sessile growths attached to it.

Microscopically, these tumours resemble one another in every particular. They are composed of small cells with rounded nuclei of much the same size, and relatively little cytoplasm, which usually forms a fine ring round the nucleus, but sometimes is in the form of one, two or more processes which blend with the processes of other cells. All the cells are irregular in shape, their angles being prolonged into fine fibres which form a fine reticulum in all parts of the tumour. Some of the cells have two or more rounded nuclei, and some are rather larger than the majority and resemble very closely the medium-sized glia cells of normal glial reaction.

The arrangement of the cells is to some extent perivascular, as each vessel is outlined by a fairly definite sheath of cells which seem to be attached to its wall. From this they spread out in broad fern-like clusters, so that in the thicker parts of the growth no interval is seen between the cells surrounding different blood-vessels.

In paraffin sections cut at six microns, the cells are fairly closely packed, but not so close as in lymphoid tissue, which thicker celloidin sections resemble to some extent; the interval between the cells is at least as wide as the cell body. Arrangement in small rosettes is seen in some parts of the growths, but is not so common as to be a characteristic feature.

The blood-vessels are of fairly large size with well-formed fibrous tissue walls and a thin endothelial lining; and they are obviously in process of forming new channels, as small buds can be seen to spring from the older vessels all along their course. In sections which cut a vessel transversely there are usually to be seen small, almost capillary channels in the adventitia, and sometimes as many as four or five channels of approximately equal size are seen running together. This appearance is similar to that seen in Case 17, but is even more marked.

The tumours do not tend to invade the substance of the brain or cord but are separated from it by a thin layer of pia mater. Nor do they infiltrate the nerves after these leave the tumour (see fig. 18).

Case 30 presents a condition which, I can only suppose, is a transition

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The cortex of the temporal lobe is invaded, and the tumour is adherent to the dura mater over an area of about 3 mm. anteriorly.

On section it presents a very irregular appearance, with splashes of yellow and black (after formalin fixation). It is granular on the surface and fairly well defined from the brain tissue, though on attempting separation it leaves a granular deposit behind. It is apparently separated from the brain tissue in places by a thin layer of arachnoid tissue.

Microscopically this is a very cellular tumour, composed of a great variety of cells, and with a great number of giant cells, either multinucleated or with ring nuclei around their periphery. The latter are mostly grouped together in the neighbourhood of large vessels. Many of them are globoid in shape, others fusiform or pear-shaped with long processes; some show mitotic figures. Smaller multinucleated cells are scattered all through the tumour, but the great majority of the cells present are small cells with small nuclei and relatively abundant cytoplasm, running off into shorter or longer fine processes. In the parts of the tumour neighbouring on the brain tissue, areas of necrosis are very plentiful; in these the nuclei are pyknotic or granular and indefinite.

Large blood-vessels are very numerous, many of them surrounded by small round cells resembling lymphocytes, but with rather more cytoplasm. Plasma cells are not seen. Of the smaller vessels some have fairly definite walls, but capillary vessels are very scanty, those present being in the peripheral parts of the tumour, and being probably the blood-vessels of the original nervous tissue.

In sections stained by Bielschowsky's method, no nerve fibres can be seen, but faintly staining fibres of varying thickness are plentiful. The large cells do not show any special staining by this method, and their processes are only faintly stained (see figs. 19 and 20).

By Weigert-Pal staining no myelinated nerve sheaths can be found, at least in the more central parts of the tumour.

Neuroblastoma.

Case 32.—T. H., aged 35 (physician, Dr. Farquhar Buzzard). Admitted, April 5, 1917. Died, August 29, 1917.

History.—In March, 1911, the patient fell down and was unconscious for a quarter of an hour, but was able to walk home later. Two days later he had another attack, followed by severe occipital headache. After this he had good health until December, 1912, when he had another seizure accompanied by headache. Since that time the headache had been constant. In October, 1915, his sight began to fail, and since Christmas, 1916, he had been quite blind.

In July, 1916, he lost the sense of smell, and in October, 1916, his gait became unsteady. Optic atrophy was present at the date of admission to hospital.

Operation, April 26, 1917. The first stage of a subtentorial decompression was performed, and this was completed on July 20, 1917.

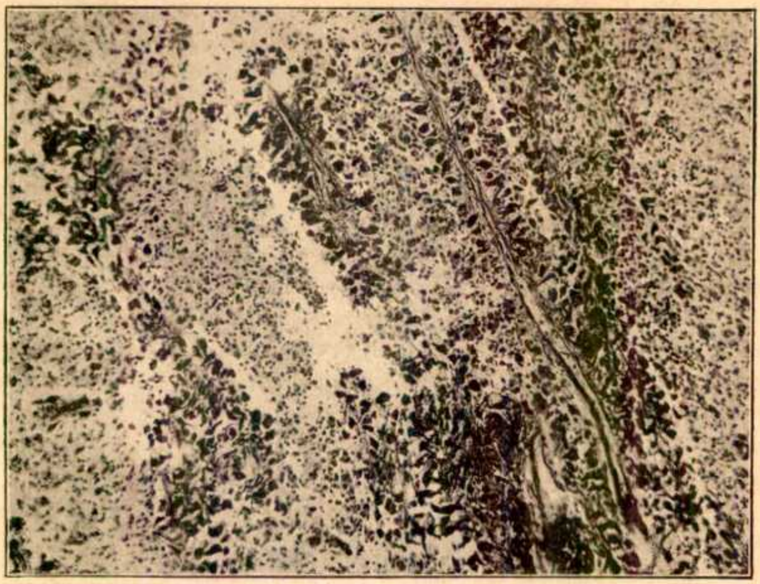


FIG. 21.—Case 32. T. H. Neuroblastoma. A general view of the perivascular grouping of large pyriform cells. (Heidenhain's hæm. Zeiss 16 mm. obj.)

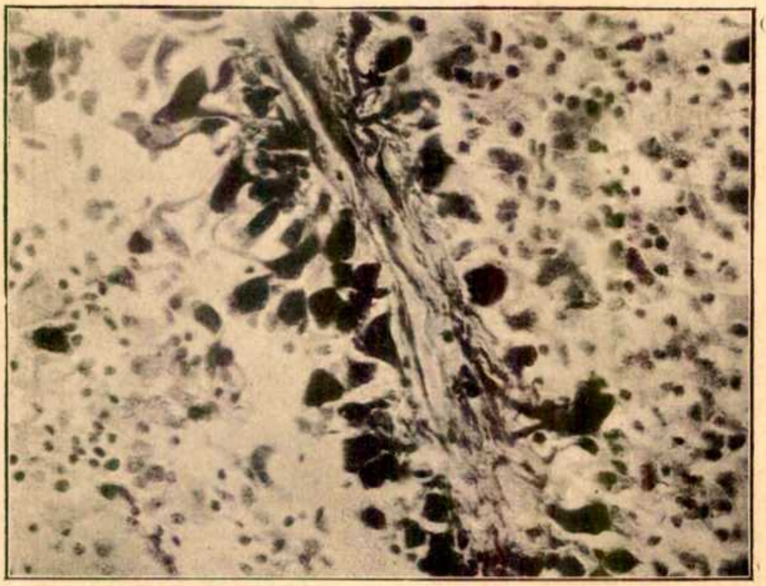


FIG. 22.—Case 32. T. H. Neuroblastoma. High-power view of same area. The large (? nerve) cells are seen ringing a small vessel with whose walls their processes join. (Heidenhain's hæm. Zeiss 8 mm. obj.)

Macroscopic appearances.—A small sub-cortical tumour is present extending to the posterior horn of the lateral ventricle, and lying under the cortex in the posterior part of the temporal lobe; the tumour is rounded in outline but not clearly delimited from brain substance. It measures in sagittal diameter 4·5 cm., in coronal 2·5 cm.

Microscopically the tumour is composed of cells of the glial type which are for the most part fairly large, globular or fusiform, with a considerable tendency to glial fibre formation, more in some parts than in others. In some places there is a fairly thick felt work of glial fibres, with relatively few glial cells; in other parts there are collections of large fusiform cells, which surround a blood-vessel in a single or double ring, being attached to its walls by one or two processes and sending out other processes into the surrounding tissue. In some parts of the tumour most of the blood-vessels are outlined by rings of such cells (see figs. 21 and 22).

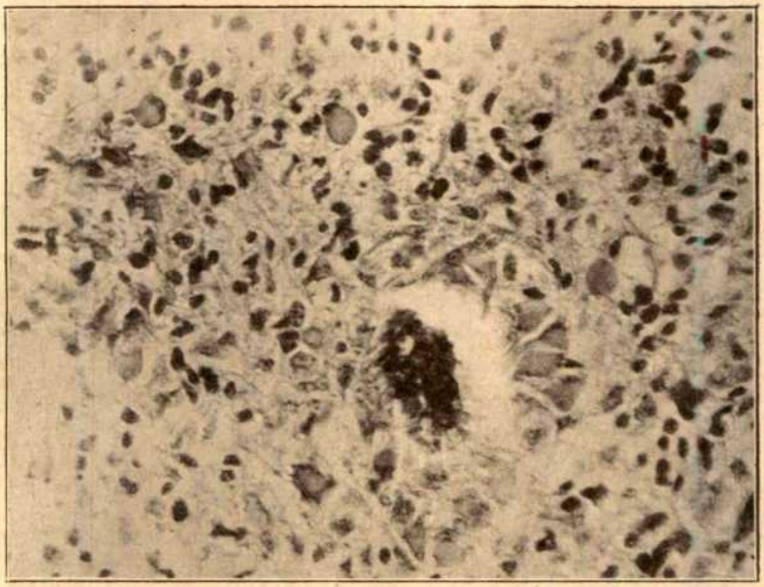


FIG. 23.—Case 32. T. H. Neuroblastoma. Showing arrangement of large cells round vessels. No darkly staining nerve-fibres are seen. Compare with figs. 19 and 22. (Bielschowsky's method. Zeiss 8 mm. obj.)

Elsewhere in the tumour the cells are irregular in size and shape, with a tendency to have more than one nucleus. The neighbouring brain tissue is compressed as is shown by concentric lines of glial tissue, and there is a definite zone of division between brain matter and tumour formed of these lines. In the tumour tissue, both in the lymph spaces and lying free in the tissue between the collections of large cells described above, there are aggregations of cells resembling compound granular corpuscles.

In some parts of the tumour there are areas of cells and fibres which closely resemble the structure of a posterior root ganglion. Giant cells measuring 30 microns or more, either of glial or nerve cell type, with one or more nuclei, are present in places.

By Bielschowsky's staining method (see fig. 23) a few axis cylinders are present in most parts of the tumour, but they seem to be most numerous in those parts which are composed chiefly of smaller types of cell. In the neighbourhood of the large globoid and fusiform cells they are not numerous if we count only those which stain a deep black, but there are numerous fibres, some thick, others finer, which stain greyish with the silver and which can be seen to arise from the large cells. It was impossible to trace any fibre for a distance from its parent cell, or it is possible that a similar connection might have been established between these paler staining fibres and the darkly stained fibres, to that which it was possible to trace in Case 34; but the way in which the processes of the large cells stained with Heidenhain's hæmatoxylin, i.e., very much more darkly than any glial fibres, suggests that they are more closely related to nerve than to glial fibres. By the Weigert-Pal method some fine myelinated sheaths are to be seen in the peripheral parts of the tumour, but no fibres are present in the more central parts. Those present seem either to have been left behind or regenerated around partially damaged axis cylinders.

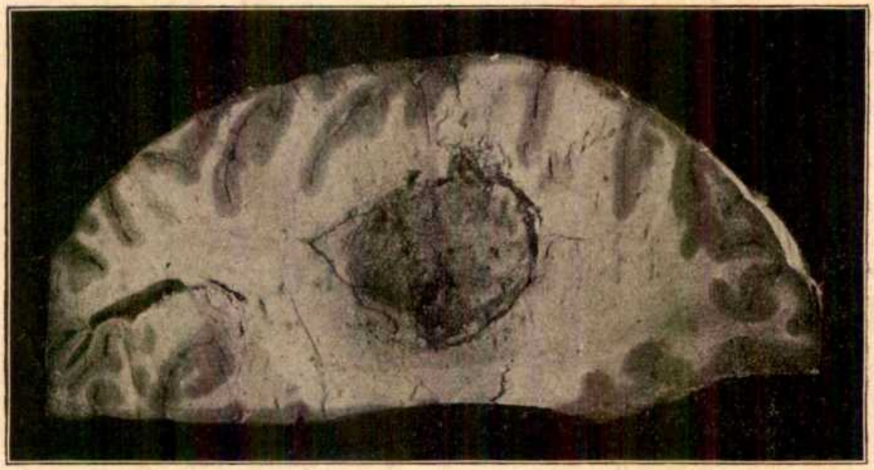


FIG. 24.—Case 33. Pte. E. Neuroblastoma. Horizontal section through the tumour.

Neuroblastoma (Malignant.)

Case 33.—Private E. (physician, Dr. Taylor). Admitted December 5, 1916. Died January 15, 1917.

History.—Six weeks before admission the patient had a septic thumb resulting from a cut. He was in bed for a week with this. Two weeks later the thumb became worse and he at that time lost the use of the arm and leg

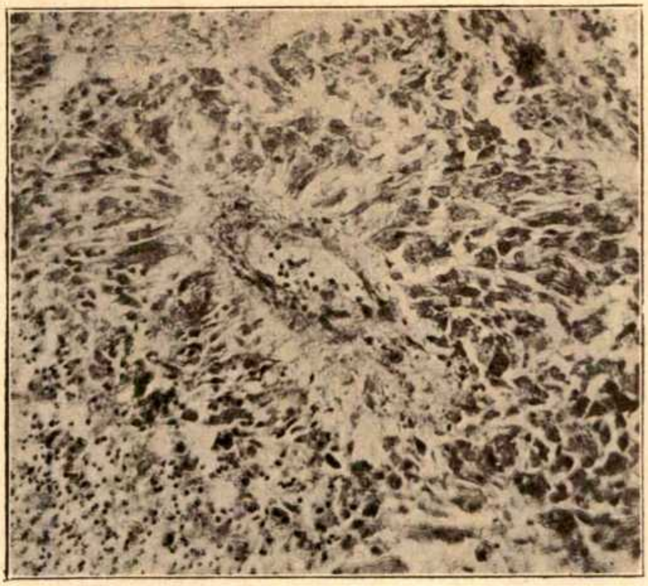


FIG. 25.—Case 33. Pte. E. Neuroblastoma. General view of the arrangement of the large cells round a vessel, with degenerated areas more distally. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

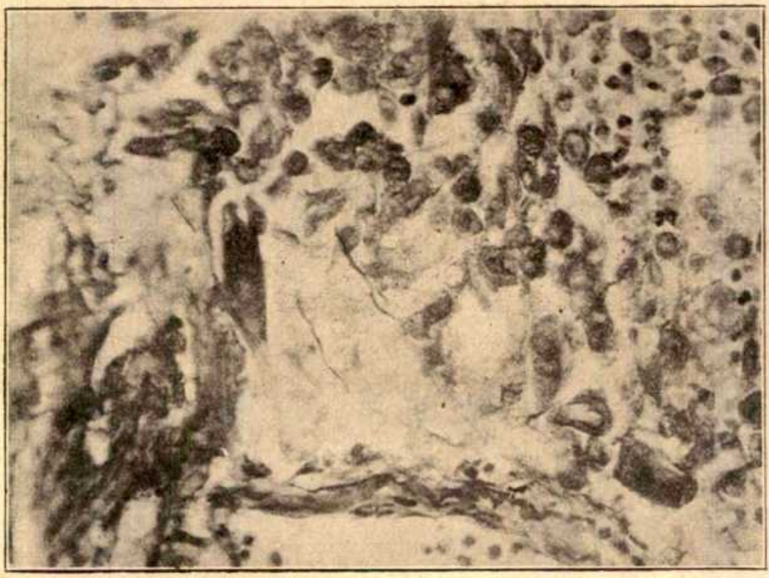


FIG. 26.—Case 33. Pte. E. Neuroblastoma. Field showing numerous nerve-fibres and wall of vessel to which a large (? nerve) cell is attached by a firm process. (Bielschowsky's method. Zeiss 8 mm. obj.)

on the same (the right) side. He also had aphasia. On admission he had optic neuritis. He had no vomiting.

Macroscopically, the dura was noted at the post-mortem to be adherent to the skull over the left motor area. On section of the brain there was found to be a well-defined granular, greyish tumour in the left centrum ovale, 2 cm. from the cortex of the parietal lobe and 2·5 cm. from the mid-line. It extends for 5 cm. in sagittal and 3 cm. in transverse diameter. In appearance it is fairly well defined from the brain substance, especially in the outer part. There is a thin friable capsule, and, when shelled out, brain tissue remains adherent to it. Blood-vessels enter by a hilum on its inner surface. There are some hæmorrhages into the substance in this region, and a moderate degree of dilatation of the ventricles is present on the side opposite to the tumour (see fig. 24).

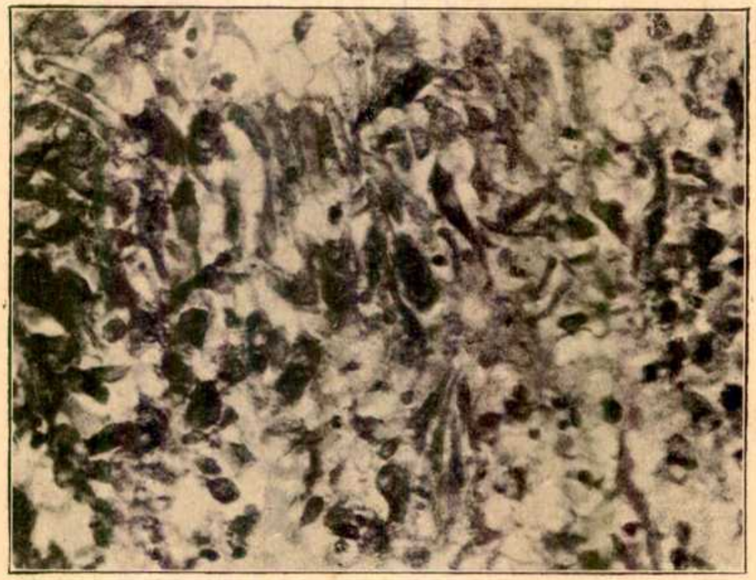


FIG. 27.—Case 33. Pte. E. Neuroblastoma. A number of nerve-cells are shown, and a few twisted nerve-fibres. (Bielschowsky's method. Zeiss 8 mm. obj.)

Microscopically there is considerable difficulty in finding a portion of the tumour which is not too degenerated for the structure to be recognized; but everywhere, even in the most degenerate parts, there are small collections of cells surrounding the blood-vessels, which are of medium size and supported by a fairly thick ring of fibrous tissue. These cells are of all shapes and sizes, but among them is a large proportion of giant cells with one or, more commonly, several nuclei. These have long thick processes, which can be traced for some distance; usually one of these is longer and thicker than the others. Many of these processes are attached to the vessel walls, but this arrangement is not so definite or so frequently seen as in Case 32 (see fig. 25).

In addition to these large cells there are everywhere smaller cells, both plasma cells and polymorphonuclear cells being plentiful, especially in the neighbourhood of degenerated areas, but small rounded cells which it is impossible to classify are also numerous. In sections stained by Bielschowsky's method very numerous axis cylinder and other nerve fibre processes are seen, some of which can be seen to arise from the large cells. These processes are all very contorted and irregular, and in places swellings which suggest "Boules terminales" can be made out. The character of these processes and their presence in the central parts of a tumour which shows such great degenerative changes, makes it almost certain that they are derived from the tumour cells (see figs. 26 and 27).

By Nissl staining it is impossible to say that there are any granules in the cells, but some cells stain more irregularly and patchily than others.

There is no evidence of glial cells or fibres in the more central parts of the tumour, but between it and the healthy brain tissue there is a fairly wide zone of thickly felted glial tissue with numerous cells, which resembles very closely the structure of a glioma. It is through this zone that the tumour shelled out. No myelinated fibres could be found by the Kultschitsky-Pal method (see figs. 23-26).

Neuroblastoma or Ganglioneuroma.

Case 34.—M. B., aged 26 (physician, Dr. Stewart). Admitted August 9, 1917. Discharged I.S.Q., October 11, 1917. Readmitted June 10, 1918. Died June 27, 1918.

History.—Headaches started after the birth of a baby, two and a half years before admission, and were very severe, especially behind the right eye. Her sight deteriorated from that time onwards.

On admission she was seen to be a case of acromegaly, with the typical enlargement of cranium, tongue, hands and feet, and underhung lower jaw, so that the teeth could not come together; she also had brown pigmentation of both axillæ and on the skin of the abdomen.

Macroscopic appearances.—The whole base of the brain is covered with a nodular tumour mass, the nodules being more or less distinct from one another, but joined by their capsules. The whole mass reaches from the olfactory bulbs to the antero-inferior surface of the pons.

Over the region of the olfactory bulbs the tumour has to some extent been removed (by operation). Posterior to this the tumour mass is diffusely stained with hæmorrhages, and extends antero-posteriorly for 9 cm., laterally for 5 cm.; vertically the greatest measurement is 4·5 cm. (see figs. 28 and 29).

Of individual tumour nodules the largest measures 3 cm. in diameter, the smallest 7 mm. They do not infiltrate the brain at any part, being attached loosely to the meninges.

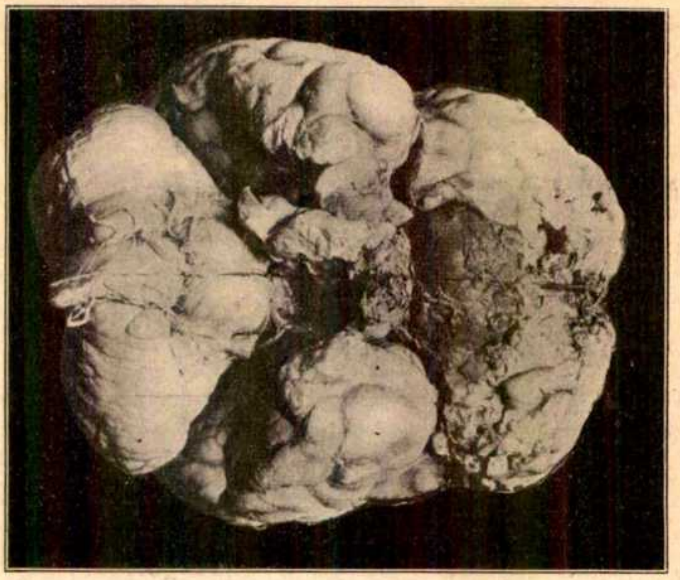


FIG. 28.—Case 34. Mrs. B. Ganglioneuroma. View of tumour from the base. The posterior part of the tumour on the left side of the mid-line has been removed for histological examination.

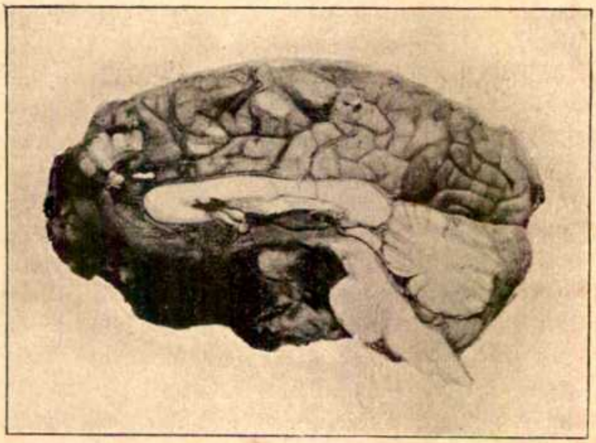


FIG. 29.—Case 34. Mrs. B. Ganglioneuroma. View of section between hemispheres of brain. The dark blood-stained area anteriorly is due to exploratory operation.

No trace of the pituitary body can be found. The tumours are pressed more into the right frontal and temporal lobes than the left: they push the right temporal lobe altogether aside from the crus cerebri on that side.

Microscopically.—The tumour is formed of two apparently different structures. In places there are groups of large, multipolar, and often multinuclear cells with a large nucleus, clearly marked nucleolus, and darkly staining cytoplasm, lying in a matrix of loose tissue which resembles the ground substance of the brain and spinal cord.

In other parts the tumour is composed of a mass of round cells with scanty cytoplasm, and with little or no ground substance, as shown by the ordinary staining methods. Lying around and among these cells are bands and wider strips of fibrous tissue which stains yellowish pink by van Gieson's stain, and is often arranged in short bundles, giving a very similar appearance to that seen in "neuro-fibromata." In this fibrous tissue are seen many cells of the large multipolar type.

When examined by Bielschowsky's method, it is seen that these two apparently different structures are of very similar nature, as everywhere there are darkly staining, clearly cut lines running in all directions through the tissue. These give the staining of nerve fibre processes, and are seen to arise, not only from the large multipolar cells, but also from some of the cells of smaller size. Although they cannot be traced through the cell body as definite fibres, it is seen in specimens which have not been differentiated with acetic acid that the cells which give rise to them are stippled over with dark spots, which other cells do not possess. In differentiated sections this appearance is not seen, and the origin of the nerve fibres is not so definite, as the processes of the cell only stain slightly more darkly than the cell body and it appears that the characteristic black staining is only attained when the fibre has extended some distance away from this. Where it is possible to trace the process for some distance it is seen that it gradually becomes darker, and is collected into a closer strand after extending for about the length of the cell body away from it, but that even at a distance of five times the length of the cell body (about 100 microns) it is still not so dark as the fibres which run near it. In the areas of small round cells the fibres are also numerous, but do not appear to spring from the smallest cells but from small multipolar cells which lie here and there among them. In act the distinction between the appearances of various parts of the tumour is very superficial, as all contain cells which resemble ganglion or motor nerve cells in greater or less numbers.

Weigert-Pal sections show no evidence of the formation of myelin, although here and there it is possible to see myelinated fibres lying by ones and twos. These probably come from cranial nerve roots which have been infiltrated by the tumour.

Nissl staining shows very little. In some of the cells the peripheral area of the cell body stains rather more darkly than the rest of the cytoplasm, and this area has a slightly granular appearance, but nothing resembling a true Nissl granule was seen.

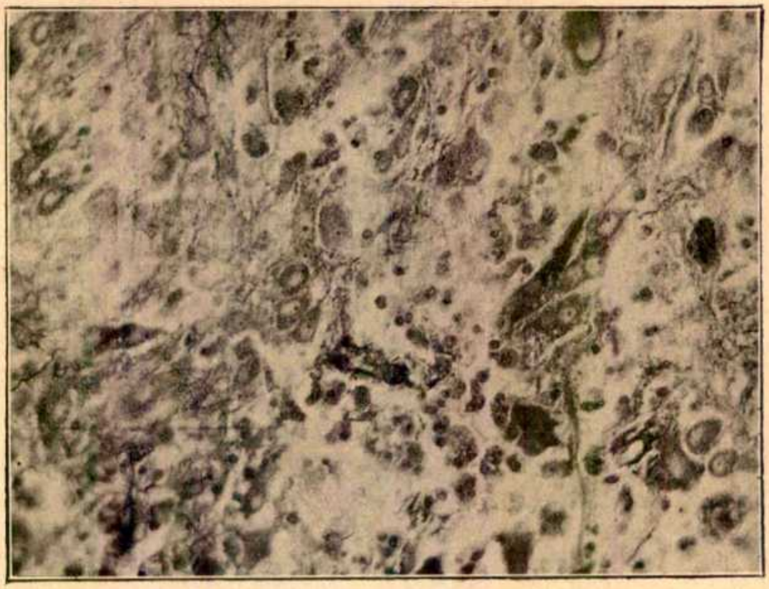


FIG. 30.—Case 34. Mrs. B. Ganglioneuroma. High-power view of ganglion cell area showing numerous black nerve-fibres and nerve-cells. (Bielschowsky's stain. Zeiss 8 mm. obj.)

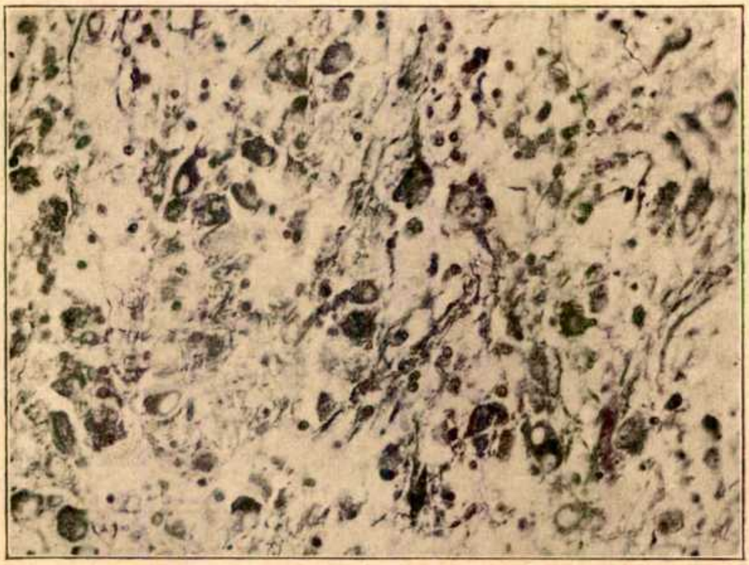


FIG. 31.—Case 34. Mrs. B. Ganglioneuroma. High-power view of ganglion cell area. Note amitotic division of nerve-cells. (Bielschowsky's stain. Zeiss 8 mm. obj.)

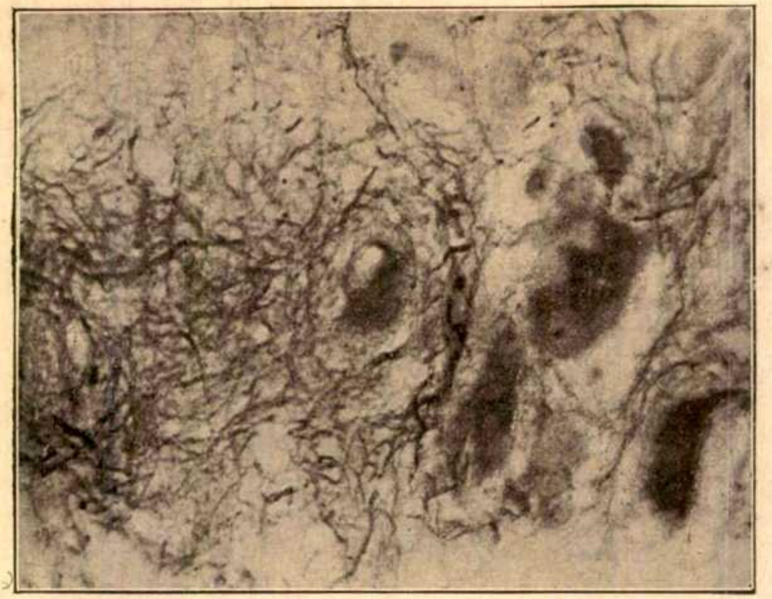


FIG. 32.—Case 34. Mrs. B. Ganglioneuroma. High-power view showing dense network of nerve fibres in a less cellular part of the field. (Bielschowsky's method. Zeiss 8 mm. obj.)

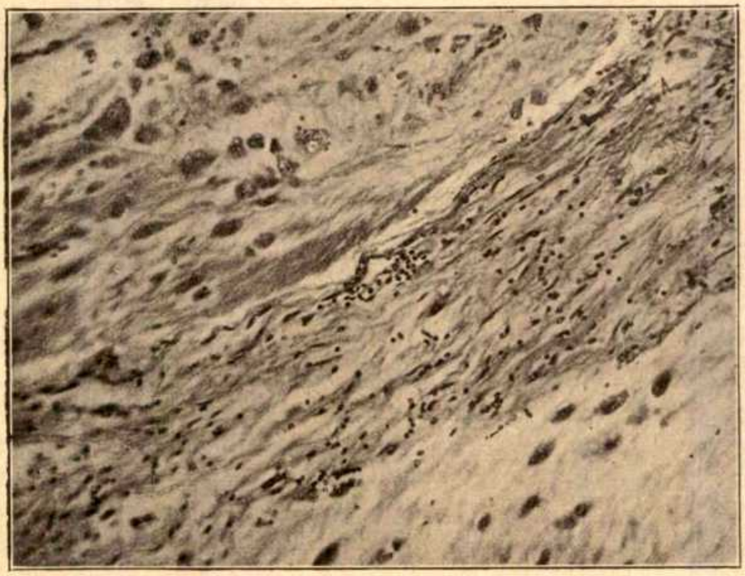


FIG. 33.—Case 34. Mrs. B. Ganglioneuroma. Between two areas of fine nerve-fibres is nucleated zone of (? sheath) cells. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

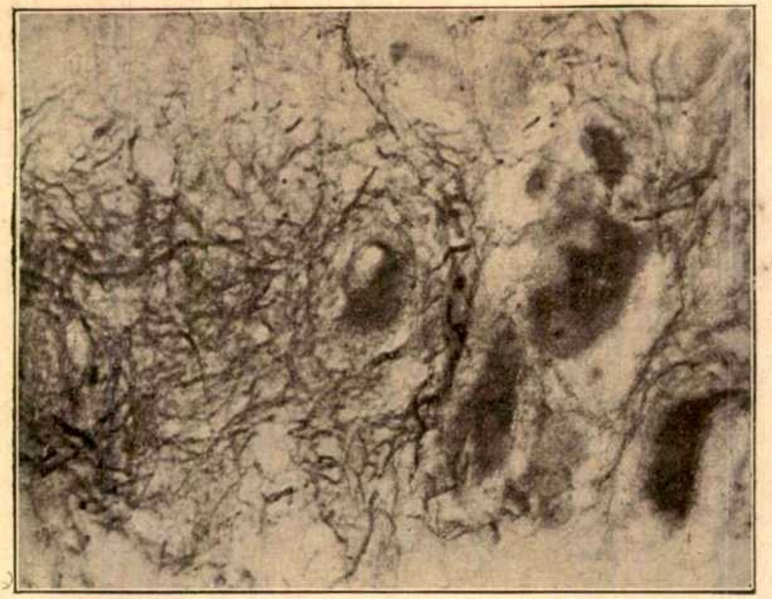


FIG. 32.—Case 34. Mrs. B. Ganglioneuroma. High-power view showing dense network of nerve fibres in a less cellular part of the field. (Bielschowsky's method. Zeiss 8 mm. obj.)

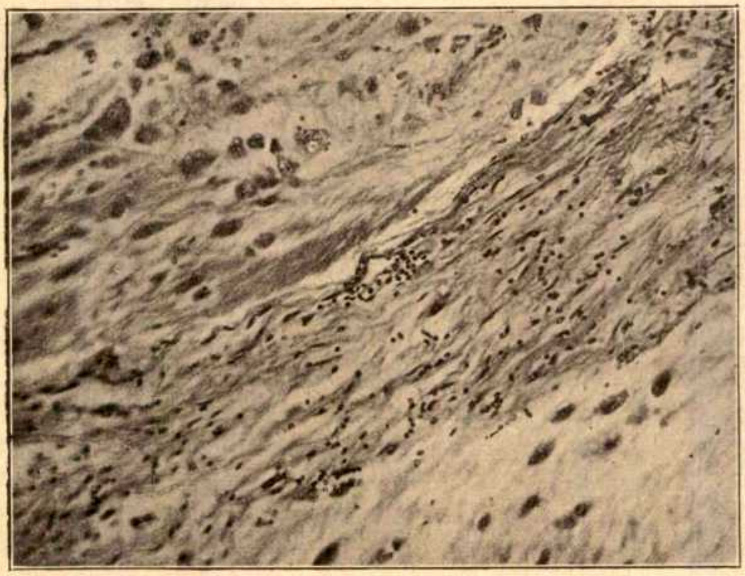


FIG. 33.—Case 34. Mrs. B. Ganglioneuroma. Between two areas of fine nerve-fibres is nucleated zone of (? sheath) cells. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

from tumour to healthy brain tissue is marked off by a zone of glial cells, which may be gliomatous in nature (as their close setting suggests) or proliferated glial cells produced by reaction in the normal tissues. There is no attempt at encapsulation of the tumour, and it separates from the brain substance through this glial zone.

Cases 31 and 32 are less definitely neuroblastomata, but their resemblance to one another and the appearance which they had in common with Cases 33 and 34 seemed to justify the diagnosis. In both there are areas of typically gliomatous appearance, and other areas in which large pyriform and conical cells are grouped together, often in relation to blood-vessels.

In Case 32 (fig. 21) this relationship is quite remarkable, many small blood-vessels being outlined by rings of pyriform cells, which seem to be attached to them by a strong process which stains intensely black by Heidenhain's hæmotoxylin, but does not stain so deeply by Bielschowsky's method. Under higher magnification the process is seen to break up into two fibres which run away from one another in contact with or blending with the wall of the vessels. The nucleus of these cells is usually placed eccentrically and is not very large or vesicular, and the nucleolus is not so clearly marked as in Cases 33 and 34, so that it is impossible to say definitely that these are nerve cells, but it is obvious that they are not glial cells, at least not of the more mature types, nor do they, except in their relationship to the wall of a vessel, suggest spongioblasts.

By Bielschowsky's method very few definite black nerve fibres are seen, but no field of the tumour is quite free from them, so that the suggestion that they are old nerve fibres from the invaded brain tissue does not seem to be altogether warranted. Thick fleshy bands which stain more deeply than glial or connective tissue by the silver stain, and which are obviously the same as those which stain intensely black by Heidenhain's hæmatoxylin, are seen to proceed from the globular and pyriform cells, and run in all directions through the field. In their staining reactions these processes are very similar to the nerve processes as they leave the cells in Case 34.

Certain parts of the tumour, especially towards the periphery, are typically gliomatous, but other parts close to the surrounding brain substance are composed of undifferentiated round cells, only a few of which have any obvious processes.

Case 31 is similar in many ways, but appears to be more malignant. Here again the larger cells are grouped together in areas round blood-vessels. Many of them are elongated cells with one or two nuclei and thick fleshy processes which can be traced away from the cell body for a considerable distance. Their nuclei correspond closely to those of nerve cells of the pyramidal type. Many of them are in process of amitotic division similar to that seen in Cases 33 and 34.

The smaller cells are rounded or elongated, and many of them resemble glial cells, others are quite undifferentiated. Processes considerably thicker than glial fibres run everywhere through the tumour, both among the larger and the smaller cells, but there is no evidence of nerve-fibres by Bielschowsky's method.

This tumour appears to be a connecting link, as it were, between Cases 32 and 33. The large cells resembling nerve cells bear the same relation to the vessels in all three, and are very similar in appearance, arrangements and in methods of cell division in Cases 31 and 33, whereas other parts of the tumour, in Case 31, bear a closer resemblance to Case 32. It is to be noted that the histories in Cases 31 and 33 are very short, which is in accordance with their histological evidences of malignancy.

The points in common between the three tumours briefly are :—

(1) They are unencapsulated but clearly defined tumours of the centrum ovale.

(2) They are composed of two different types of cell, of which the larger have definite thick processes which can be traced some distance from the cell body, and these cells are arranged round blood-vessels with the walls of which some of their processes blend.

Cases 31 to 34 thus give four different pictures of nerve-cell tumours, two of a comparatively benign, and two of a definitely malignant type. Cases 31 and 32 suggest an origin from cells which have not yet been differentiated into neuroblast and spongioblast, but give rise to rudimentary cells of both types. The cells surrounding the vessels in Case 32 are extremely like some of those described in the development of the posterior root ganglion, but retain also a resemblance to glial cells in their nuclei and staining reactions. Cases 33 and 34 are formed of more mature nerve cells, and in neither is there any evidence of glial tissue.

It has been stated that tumours composed of both glial and nerve-cells do not exist, and the supporters of this view would doubtless say that there was no proof that any of the cells in either Case 31 or 32 were definitely nerve-cells, and in this the staining reactions by Bielschowsky's method would support them. The only answer to this rests in the character of the processes of the large cells, which are fleshier and longer, and, in fact, more definite than those of any known form of glial cell. And it seems not unlikely that in tumours which owe their origin to undifferentiated cells of the neural epithelium included in the brain matter, and which have some tendency to malignancy, the formation of nerve-cells should be imperfect, so that they show neither Nissl granules nor neurofibrils. It is surely in accordance with all views on tumour formation that a cell which has the potentiality of developing into all forms of nervous and glial cells should give rise to cells unlike any mature form, but resembling both types in some features.

None of the cases in this series showed any myelin sheaths by the Weigert-Pal (Kultschisky-Pal) method; nor did any show definite Nissl granules. All that can be said is that some of the cells retain a faint blue stain round the periphery of their cytoplasm. This is similar to what is described by Dunn as Nissl granules, and it undoubtedly has some relation to them, but it is too slight and indefinite to form a criterion on which to base a diagnosis. This rests in the end, and definitely, on the presence of nerve-fibres (as shown by silver stains), and the relation of these fibres to the cells, although in the absence of this there may be good grounds for assuming that the tumour contains immature nerve-cells.

Acoustic Nerve-tumours and "Central Neurofibromatosis."

In the present series there are six tumours of the acoustic nerve, in one of which a bilateral acoustic nerve-tumour was associated with multiple "neuro-fibromata" of the nerve-roots, a central tumour of the cord and a cortical brain tumour. As far as the histology of the tumours is concerned, this case may be treated along with the others, as what differences existed were only slight, and due more to the site of the tumours than their nature.

It may be said at once that these tumours form a class by themselves. Once their histological characteristics are recognized, they should not be mistaken for any other form of tumour with the single exception of the "neurofibromata" of von Recklinghausen's disease, to which they are closely allied.

They are composed of cells which resemble the connective tissue type in having an elongated nucleus and cytoplasm which tails off into a spindle-shaped process at either end, but which differs from it in staining reactions, e.g., with van Gieson's stain, which gives the processes more of a brick-red colour than the pure fuchsin staining of connective tissue; thus the ring of fibrous tissue round the vessels is clearly marked off from the cells of the tumour. The cells have a tendency in many places to be arranged in what Cushing has called a "palisade" manner, nucleus lying by nucleus, and cytoplasm by cytoplasm, giving a banded appearance to the section.

In teased specimens, and where the texture is loose, the cell processes can often be seen to split up into two or more fibres after leaving the cell, differing from connective tissue fibres in this as in their greater tendency to degenerative changes.

In addition to these cells, there are areas of a looser texture in which multinucleated cells are common, and the ground substance is formed of small rounded cells with scanty cytoplasm, which tends to run off into several thin, poorly formed processes—a type of cell suggesting myxomatous or glial tissue. The relative proportion of these two different types of tissue varies in different cases, and in different sections from the same case, but usually both are present to some extent. The blood-vessels are usually formed of a definite endothelial lining, with a thin fibrous tissue layer surrounding it. Sometimes the vessel walls show hyaline degeneration. Fatty and mucinous infiltration of the tissue is very common. In the tumours of this series myelinated fibres were extremely scanty, but a few were found in the peripheral parts of the tumour. No nerve-fibres were found by silver staining methods in any of the tumours examined.

The association of bundles of fibrous cells with areas of looser, more reticular tissue, taken along with the staining reaction and arrangement of the fibrous cells, gives a histological picture unlike that of any other tumour. From their histological appearances they have been classed as fibromata, fibroglioma, myxo-sarcoma, and gliosarcoma, according to the predominating features of the tumour or the whim of the observer. Although areas of fibrous tissue are sometimes seen in them, these are obviously not the essential structure of the tumour, but are probably due to degeneration of tumour cells and replacement by fibrous tissue. For a similar reason cysts are often found. Both these features are shown in the tumour of the cord in Case 35. And an examination of a number of these tumours from the macroscopic point of view is enough to satisfy the observer that in their manner of growth they have little in common with sarcomata, as they do not tend to infiltrate either bone, meninges, or brain tissue. They are usually nodular on the surface, and covered over with a layer of arachnoid. On section some are granular, and resemble endotheliomata; others show the "watered-silk" appearance seen in fibromata, but of a coarser type, and with a rougher cut surface. Small areas of hæmorrhage and softening are frequently seen.

The following is a case of the rare condition described as

Multiple "Central" Neurofibromata.

Case 35.—N. R. S., aged 22 (physician, Dr. Farquhar Buzzard). Admitted March 30, 1917. Died April 11, 1917.

History.—There was a gradual onset of symptoms from September, 1916, viz., headache, failing vision, deafness, dragging of the left leg, and then wasting of the left side of the body.

Operation, April 11, 1917. Cerebellar decompression. No tumour found. Patient died shortly after from respiratory failure.

Macroscopic appearances.—Brain: (1) A tumour measuring 4·2 by 3·5 by 3·5 cm. is present on the postero-internal border of the left occipital lobe, immediately above the calcarine fissure. This is fairly soft and covered by felted pia-mater.

(2) A tumour of about the same size, firmer, nodular and of a glistening surface, is found in the right cerebello-pontine angle.

(3) There is a similar tumour 3 by 2 by 1·6 cm. in the left cerebello-pontine angle.

(4) The whole cervical region of the cord contains a central tumour which causes great enlargement, the greatest measurement being 2·5 cm. transversely. On section of the cord at this level, the tumour is seen to extend the length of the cervical region, with cavity formation in its centre. This is somewhat irregular, but lies usually towards the centre of the cord, rather to one side. In some places there is no cavity, e.g., towards the upper end of the cervical region, but a rounded mass fills the centre of the cord, and above and below the tumour a smaller cavity runs up and down in the region of the posterior horn on one side; whereas the rest of the cord appears normal.

(5) Many of the nerve-roots, both anterior and posterior, are enlarged into fusiform swellings. On careful examination it can be seen that this process is almost universal, but some of the swellings are very minute. There is, however, a larger swelling about 1 cm. in diameter on the left side of the cervical enlargement, at the level of the tumour, which has flattened out the side of the cord.

Microscopically these tumours are all of very similar character, their cells being mostly fusiform, and resembling fibroblasts, but staining a brownish red with van Gieson's stain, and thus standing in sharp colour contrast to fibres of connective tissue round blood-vessels. The cell fibres are fairly thick and are arranged in loose bundles or whorls, often showing the palisade arrangement of nuclei and cytoplasm, which is seen in Case 40. This is seen especially well in

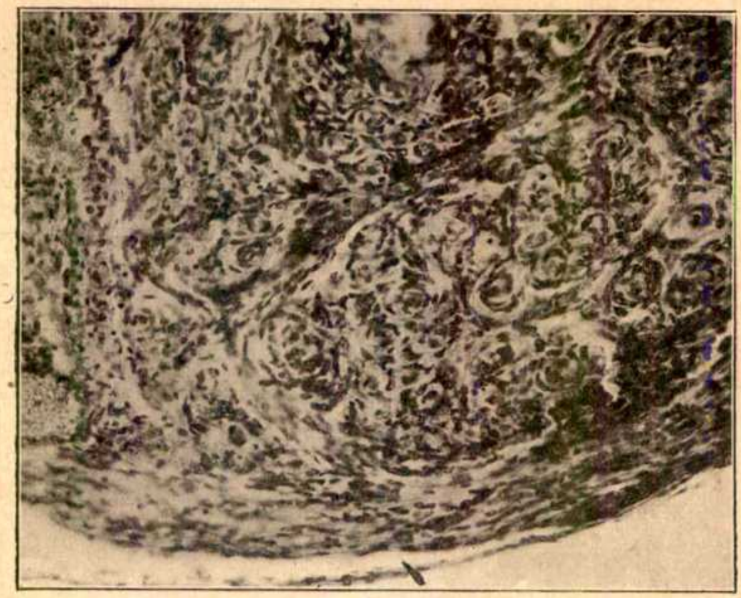


FIG. 34.—Case 35. N. R. S. Multiple central neurofibromata. Emerging nerve-roots just below central tumour of the cord showing the earliest stages of neurofibromatosis.

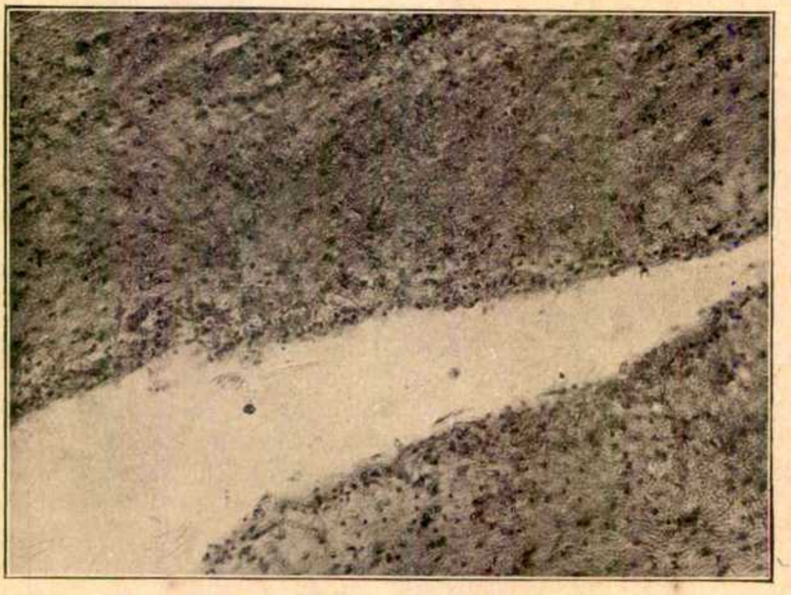


FIG. 35.—Case 35. N. R. S. Multiple central neurofibromata. Wall of cavity below tumour of cord showing slight glial increase in innermost layer. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

the central tumour of the cord and also in the large tumour lying at the side of the cervical enlargement (see fig. 38).

In some places the cells are more rounded with relatively little cytoplasm and at first sight resemble lymphocytes, but their cytoplasm is prolonged into fine processes which run a considerable distance from the cell body. There is everywhere a tendency to œdema, as shown by the separation of bundles and cells. The blood-vessels are for the most part well formed, their walls being formed of an endothelial lining and a definite fibrous tissue coat.

In the central tumour of the cord there is in parts a great formation of dense fibrous tissue, in rounded masses which are ringed round by masses of tumour cells. This is not seen in any of the other tumours either round the brain-stem or cord, and may be due to a starvation of blood supply in this central tumour. In the ponto-cerebellar angle tumours the blood-vessels are much more poorly formed than in the tumours of the cord, being simply outlined by endothelial cells. They show more tendency to œdema than the cord tumours.

The tumour in the cervical region of the cord is surrounded by a zone of extreme glial proliferation with the formation of enormous glial cells with a large cell body which is prolonged into thick processes which can be traced for a considerable distance. Some of these cells are multinucleated. The cavities in the cord are also ringed by a glial layer, the innermost layer of which contains a larger number of nuclei than is seen elsewhere, but this cell increase is not nearly so great as in parts of the subpial layer, both in the cervical and dorsal regions of the cord. It is seen also in the posterior longitudinal fissure in the upper dorsal region, just below the level at which the fissure reappears after having been lost as a result of the tumour in the centre of the cord. At this level there is a very small extension of this central tumour, shown as a collection of rounded cells with darkly stained nuclei, lying in the posterior horn on one side. This has no connexion with the central canal of the cord, nor does it reach to the cord surface (see figs. 35 to 37).

The subpial cell increase seems to have some relation to the emergence of the posterior nerve-roots, being, in places, most marked close to them, but it is extremely patchy, and is seen sometimes on the posterior surface and sometimes on the lateral surface of the cord.

Very many of the nerve roots are in a more or less advanced stage of "neurofibromatosis," some showing the very earliest changes; and in these it seems to be possible to verify the contention of Durante, Verocay, and others, that the tumours arise from overgrowth of the cells of the neurilemma sheath of Schwann, as concentric layers of cells are seen surrounding the nerve-fibre and encroaching on its tube, so that there appears to be no room for anything but the axis-cylinder. In longitudinal sections of nerve-roots stained by iron-alum hæmatoxylin or by the Kultschitsky-Pal method, it is seen that the myelin sheath is lost in these constricted tubes, but they are seen to regain their myelin after leaving the tumour (see fig. 34).

By the Kultschitsky-Pal method it is not possible to make out any new formation of myelinated fibres, although a very few such fibres can be seen

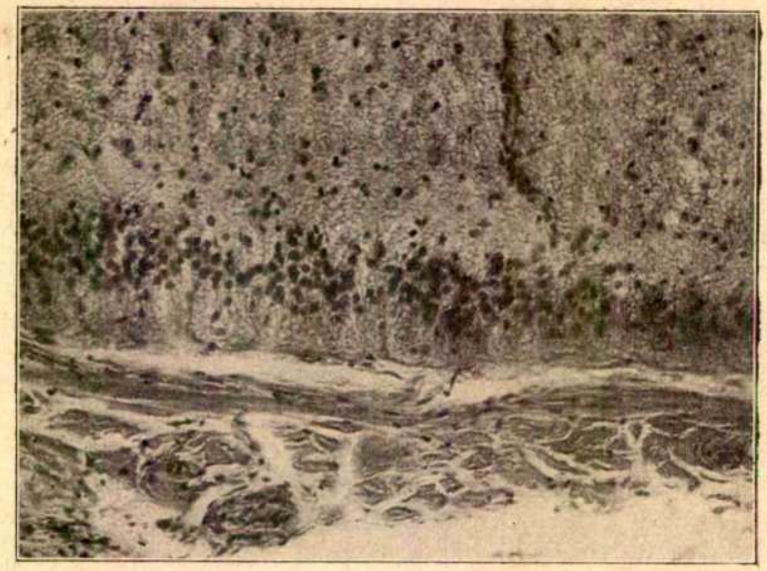


FIG. 36.—Case 35. N. R. S. Multiple central neurofibromata. Showing subpial gliosis close to point of emergence of posterior nerve-root. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

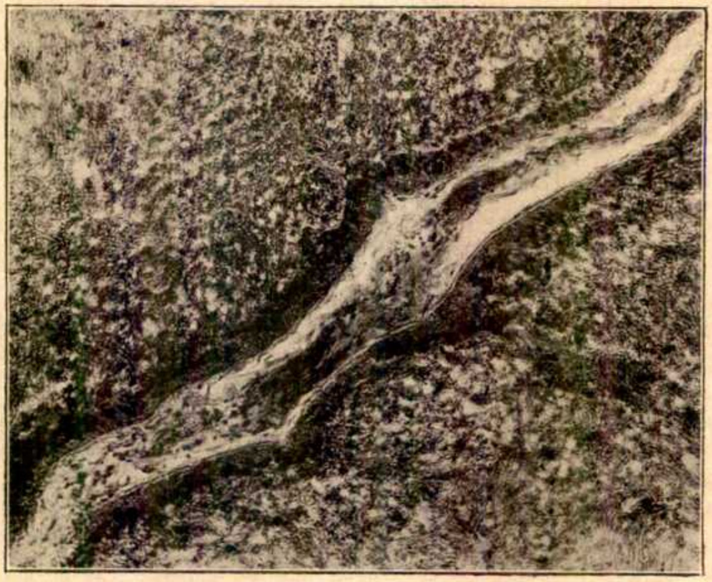
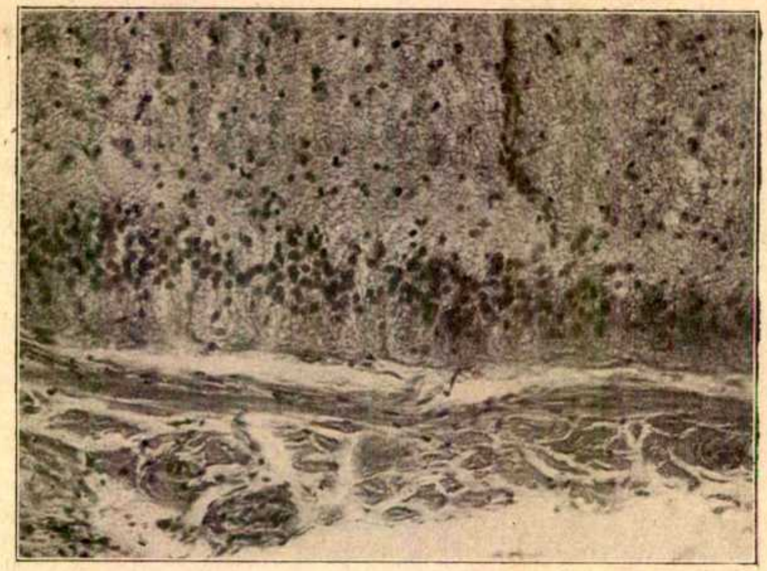


FIG. 37.—Case 35. N. R. S. Multiple central neurofibromata. Postero-median fissure below level of tumour of cord showing subpial gliosis. (Hæm. v. Gieson. Zeiss 16 mm. obj.)



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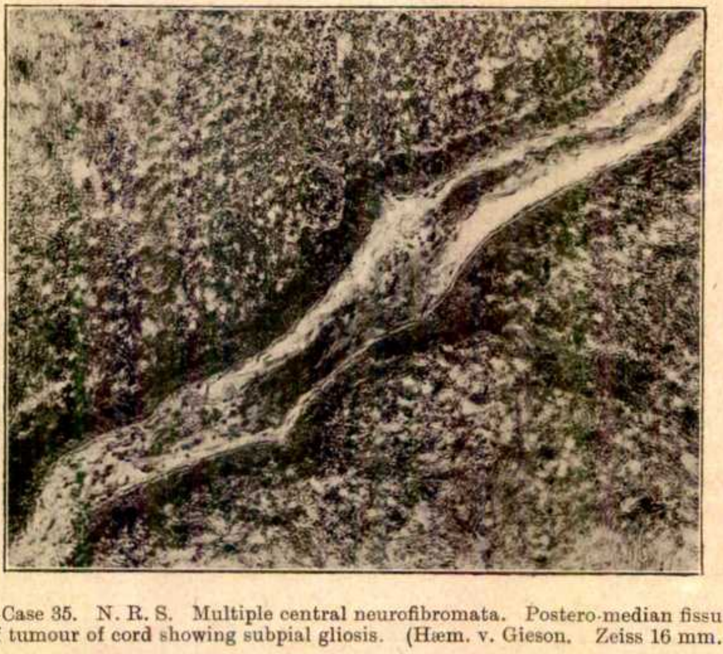

FIG. 37.—Case 35. N. R. S. Multiple central neurofibromata. Postero-median fissure below level of tumour of cord showing subpial gliosis. (Hæm. v. Gieson. Zeiss 16 mm. obj.)

better supported by connective tissue fibres than in the tumours of the acoustic nerve, and everywhere there is an excess of connective tissue, fine fibres, which take a pink stain with Van Gieson's fluid, lying between the brown staining fibres.

Although the appearances are to some extent suggestive of an endothelioma, the resemblance to the other tumours found in this case is very much closer, and there are several points in which it differs from the other endothelioma of this series.

In the first place the blood-vessels are not formed of the same tissue as the main substance of the tumour, but are always surrounded by a clearly defined layer of pink-staining fibrous tissue. There are none of the small vessels running between the cells of the tumour which are characteristic of endotheliomata.

There is also a greater distinction between the elongated brown-staining cells composing the tumour and the connective tissue fibres, and less tendency to whorl formation than was seen in the other endotheliomata.

Discussion of the Histogenesis of Acoustic Nerve Tumours.

In his recent monograph Cushing has investigated fully the point of origin of these tumours from the acoustic nerve, and considers that it usually lies within the internal auditory meatus which is always enlarged on the side of the tumour. In a case examined after this series was concluded I was able to examine the petrous temporal bones on both sides, and found the internal auditory meatus widened out anteriorly on the side of the tumour, the foramen being prolonged as a wide depression on the surface of the bone.

The relationship of the tumour cells to the nerve elements from which they arise has been the subject of considerable controversy which cannot yet be considered as definitely settled. In the light of the collected cases of multiple neurofibromatosis, either "central" or generalized, associated with tumours of the acoustic nerve, it must be considered that tumours of the acoustic nerve are closely akin to the peripheral nerve tumours of von Recklinghausen's disease, differing from them only in their greater tendency to the formation of glia-like areas, and in the absence or extreme scarcity of myelinated or bare nerve-fibres. In all probability the bundles of fibrous cells are similar in all these tumours and have a similar origin.

In this connexion it is interesting to recall the *history of the subject.*

The histology of the tumours was first observed by Virchow, who considered them to be neuromata.

But in 1881 von Recklinghausen, noting their association with better supported by connective tissue fibres than in the tumours of the acoustic nerve, and everywhere there is an excess of connective tissue, fine fibres, which take a pink stain with Van Gieson's fluid, lying between the brown staining fibres.

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This theory of origin has certainly much to support it, and provides an explanation for certain cases of multiple tumours of nerves, nerve roots, and central nervous system.

Cushing (1917) considers that the tumours of the acoustic nerve arise from undifferentiated cells at the junction of the glial elements with the sheath of Schwann. This takes place at a considerable distance from the brain stem, which is probably greater in the vestibular than in the cochlear nerve. This "transition zone" is probably an area of unstable equilibrium, and may be more so in the eighth nerve than in the other cranial and spinal nerve roots, as it is to be noted that most cases of multiple tumours of the nerve roots ("central neurofibromatosis") are associated with bilateral acoustic nerve tumours (see Case 35). In Verocay's cases, and in one of Cushing's cases, ganglion cells were found in acoustic nerve tumours. These had been observed by earlier writers, but were usually considered to be pre-existing ganglion cells in relation to the eighth nerve. Verocay, however, considers them to be an integral part of the tumours, and with this view Cushing assents.

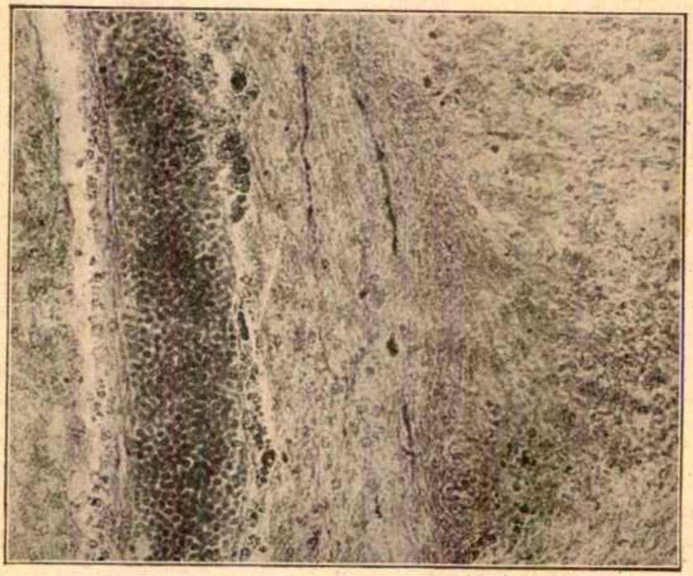

FIG. 39.—Case 36. G. M. Acoustic nerve tumour. Showing two myelinated fibres running in the neighbourhood of a vessel. (Kultschitsky-Pal. Zeiss 16 mm. obj.)

That the multiple tumours of the nerve roots in Case 35 are derived from the cells of the sheath of Schwann seems capable of ocular demonstration, as there is obvious proliferation of cells in concentric rings right in to the nerve root and encroaching on the lumen of the tube so as to cause disappearance of the myelin sheath. The axis cylinder is seen in the centre, closely surrounded by the "signet ring" of the innermost proliferated layer, and no line of tissue can be seen between axis cylinder and "signet ring."

The increase of cells in the subpial layer of glia is of great interest in this case, as suggesting that the tendency to proliferation had affected them as well as the innermost layer of the sheath of Schwann. But it is to be noted that the central tumour of the cord is formed of fibrous cells similar to those of the acoustic nerve tumours. It may be assumed that it has arisen from included elements which should have migrated to form the syncytium of the sheath of Schwann.

It is impossible to avoid the suggestion that certain "psammomata," as well as some tumours which have been described as "endotheliomata," are of the same origin as acoustic nerve tumours. To the writer it appears clear that the large cortical tumour in Case 35 is of the same nature as the other tumours in the case, although it is certainly a psammoma, and has certain points of resemblance to the endotheliomata.

It is also probable that certain of the cases of multiple psammomata in relation to the nerve roots are neurofibromatous in origin. The tendency which tumours of the acoustic nerve show to hyaline degeneration of the vessel walls is well shown in Cushing's monograph and the resulting impoverishment of the blood supply may result in fibrosis and the deposition of calcareous salts in the fibrous tissue.

While it is unjustifiable without greater knowledge to assume that the tumours of the cortex in Verocay's case were of the same nature, it seems *prima facie* more probable than when the majority of the tumours in a case conform to one type, the others, though somewhat dissimilar in histological appearances, should, at any rate, arise from the same embryonic layer, and possibly also from undifferentiated cells of a similar type.

Generalized or "central" neurofibromatosis usually commences fairly early in life, whereas single acoustic nerve tumours are rarely

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Generalized or "central" neurofibromatosis usually commences fairly early in life, whereas single acoustic nerve tumours are rarely other cause, takes on a "habit of growth." That such cells are commonly present in the "transition zone" of the nerve roots is also suggested by the cases of multiple growths in this region, and it is probable that a fuller study of the histology of the nerve root may shed more light on the etiology of tumours of nervous tissue.

In conclusion I wish to express my thanks to the Medical Research Committee, by whose help I was enabled to carry out this examination.

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THE CEREBROSPINAL FLUID IN HERPES ZOSTER, AND THE RELATION OF HERPES ZOSTER TO SYPHILIS.

W. H. BROWN, M.D., CAPTAIN, R.A.M.C.,
AND
DR. B. DUJARDIN,
Chef du Service de Vénéréologie à l'Hôpital Militaire Belge.

THIS short paper is the outcome of investigations that were being made on the cerebrospinal fluid in syphilis, in all its phases. While the patients were under actual treatment for syphilis with "606," or under observation for a long period thereafter, a number developed herpes zoster. The following questions in consequence arose:—

(1) Was the cerebrospinal fluid affected in any way in herpes zoster either in non-syphilitic or syphilitic subjects?

(2) Was there any relation between syphilis and herpes zoster?

(3) Had the administration of "606" anything to do with the development of herpes zoster?

Since Head and Campbell [2] published their epoch-making researches on the pathological changes in the posterior root ganglia, &c., in herpes zoster, little or no advance has been made as regards the etiology of this condition. During the last few years several interesting papers [3] have been published drawing attention to the possible relationship between herpes zoster and chicken-pox [5], and even their possible common origin. A large number of instances have been cited where there has been the curious incidence of chicken-pox in families after one, usually an adult member, had suffered from herpes zoster, and vice versa; also a few cases where the two diseases occurred in the same individual at one and the same time. Otherwise the etiology of herpes zoster remains a mystery, though everything points to a microbic origin.

With such profound inflammatory changes occurring in the posterior root ganglia, and secondary degenerative changes in the posterior roots and posterior column of the spinal cord in herpes zoster, it would not be surprising to find some pathological changes in the cerebrospinal fluid, due to some reaction on the part of the meninges.

THE CEREBROSPINAL FLUID.

This was examined chiefly with reference to (1) the cellular elements; (2) albumen; (3) globulin, and (4) Wassermann reaction.

For estimating the lymphocytosis, Rosenthal's and Nageotte's counting chambers were used.

As far as can be ascertained very few investigations have been made. Several French authors record very briefly a few cases but give no details regarding the numerical estimation of the cell contents. Lochelongue [4] simply states that there is usually no lymphocytosis, and if so, very slight; a statement not at all in keeping with our observations. Milian [7] states that the cellular contents are very inconstant. Achard and Lanbry [1] examined seventeen cases; in eight cases the lymphocytosis results were negative, and in the remainder very slight.

The cell contents were estimated without centrifugalizing the cerebrospinal fluid. Normal cerebrospinal fluid is practically devoid of cellular elements, except an occasional lymphocyte and epithelial cell; anything above two lymphocytes per c.mm. we have taken as abnormal. We may here state that the question of the patients being syphilitic or non-syphilitic subjects does not affect the findings in the cerebrospinal fluid. The majority of the observations were made in non-syphilitic subjects. The accompanying tables give the details of the cases—the following is a brief résumé.

(1) *The cellular elements.*—In forty-two cases the cytological estimation was made with extremely striking but inconstant and puzzling results. In the great majority of the cases (28) there was some degree of lymphocytosis, but this varied enormously, from normal (1 or 2 lymphocytes) to an intense lymphocytosis (470 per c.mm.). In ten cases the counts registered over 50 cells per c.mm. We could find no adequate explanation for these great differences. There was absolutely no relation to the intensity of the eruption as one might perhaps have expected—rather the reverse. On the whole, the highest estimates were found in those cases with a very slight abortive eruption, e.g., three such cases gave counts respectively of 136, 350 and 52 per c.mm. On the other hand, some cases with a mild eruption gave normal counts. Similarly, in cases where the eruption was extensive and acute, the lymphocytosis varied in an extraordinary way, from practically normal to a cell count of 200 per c.mm. In ten cases the counts registered within normal limits.

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made under different conditions. One of us (Captain Brown) had charge of a large skin division attached to a venereal hospital, the other (Dr. Dujardin) was in charge of the syphilis section at the Belgian Base.

TABLE I.—CAPTAIN BROWN'S CASES.

Case	Region	Remarks	Cells	Albumen	Wassermann	
					C.S.F	Blood
				Centigr.		
1	Supra-orbital	An acute case	9	40	Neg.	Neg.
2	Trigeminal	Very acute case	100	..	,,	,,
		2nd examination 1 month later	40	..	,,	,,
3	Cervical	Acute eruption	7	40	..	..
4	,,	Acute. Recent syphilitic	2	40	Neg.	Neg.
5	Dorsal	..	3	..	..	..
6	,,	Acute	126	25	Neg.	Neg.
7	,,	..	47	..	..	..
8	,,	Mild abortive eruption	136	..	Neg.	..
		2nd examination 3 weeks later	5	..	,,	..
9	,,	..	9	..	..	..
10	,,	Acute eruption	3	25	Neg.	Neg.
11	,,	..	7	25	..	..
12	,,	Very slight eruption	52	25	Neg.	Neg.
13	,,	Eruption fading 16th day	1	22	,,	..
14	,,	Slight eruption	1	25	,,	Neg.
15	,,	,, ,,	0·5	22	,,	,,
16	,,	Slight abortive eruption	350	56	,,	,,
17	11th dorsal	Very acute	200	40	,,	,,
		2nd examination 16 days later	18	35	,,	,,
18	Lumbar	Very slight case	1	40	..	..
19	,,	Mild case	0·5	22	..	..
20	,,	,, ,,	5	15	..	..
21	,,	..	66	..	..	..
22	,,	Acute. Syphilitic c̄ iritis	7	45	Neg.	Neg.
23	Sacral	..	45	35	..	..
24	,,	..	5	22	..	..
25	,,	..	20	40	..	..

TABLE II.—DR. DUJARDIN'S CASES.

1	Cervical	Latent syphilitic. Recent	..	..	..	..
2	,,	Old syphilis of seven years	0	..	Neg.	Neg.
3	Thoracic	Recent secondary syphilis	11·8	22	,,	Pos.
4	,,	,, ,, ,,	10	..	,,	..
5	,,	,, ,, ,,	2·5	..	..	..
6	Abdominal	Tabes very marked	40·8	50	..	..
7	,,	Marked tabes	88	22	..	..
8	,,	Very marked tabes	32	50	Pos.	Pos.
9	,,	Recent syphilis	4	..	..	..
10	,,	,, ,,	..	..	..	..
11	,,	,, ,,	..	..	..	..
12	Lumbar	,, ,, Neuro-recidive	92·8	2	..	Pos.
13	,,	Primary. After first injection of neo-salvarsan	246	30	..	Pos.
		2nd examination 8 weeks later	15·2	..	..	Pos.

NON-SYPHILITIC CASES.

14	Occipital	Slight eruption	470	42	Neg.	Neg.
15	Cervical	,, ,,	1·2	..	,,	,,
16	Abdominal	Acute eruption	18	..	..	..

(Captain Brown's Figures.)

In twelve cases of herpes zoster in which the question of syphilis was thoroughly inquired into and Wassermann test carefully done in both blood and cerebrospinal fever only two had had syphilis. The Wassermann tests were negative, but both had been treated for primary syphilis a short time previously in this hospital. A third case was possibly syphilitic, presenting a suspicious Argyll-Robertson pupil.

Major C. White, R.A.M.C., who is in charge of the syphilis division, and who has passed through his hands about 19,000 cases of syphilis, has kindly stated that he cannot recall having seen more than two cases of herpes zoster occurring during the treatment with salvarsan or neo-salvarsan. These patients after being discharged from hospital go to their units, &c., and consequently a herpes zoster, which is more likely to develop some time after treatment, would pass through a different channel. The interesting point, however, is the rarity of herpes zoster occurring during the course of arsenical treatment.

(Dr. Dujardin's Statistics.)

The striking feature of this series of cases is the frequent incidence of herpes zoster among syphilitic subjects. These cases were collected from among the soldiers and civilians presenting themselves for medical advice at the Belgian Base Military Hospital, and, being a garrison depot, the population was more or less stationary, and the patients consequently could be kept under observation. Within two years about 1,200 cases of syphilis in one stage or another appeared, and out of this number nine cases of herpes zoster developed thereafter, i.e., approximately 4 per 1,000 per annum. Among about 13,000 other patients only ten cases of herpes zoster were seen, i.e., less than 1 per 1,000.

It would seem therefore that there was a predisposition to herpes zoster in syphilitic subjects. This predisposition appeared more striking in the work of Head and Campbell [2]. In their investigation of twenty-one cases, which was made from a pathological point and without any preconceived ideas on the present subject, we find that fourteen of their cases were certainly syphilitics; other four probably syphilitic, i.e., more than two-thirds of the cases.

In all, sixteen cases were investigated; thirteen occurred in syphilitic subjects, three in non-syphilitic. Of these thirteen patients, ten had received arsenical treatment (neo-salvarsan) some weeks or months prior to the appearance of the herpes zoster: in two cases of primary syphilis the herpes zoster developed during the course of treatment, viz., after three injections of neo-salvarsan. One patient had had no previous arsenical treatment. There was one instance of herpes zoster (of lower abdomen) developing practically at the same time as a syphilitic nervous lesion; the following is a résumé of the case. The patient was an early case of tabes, with Argyll-Robertson pupil and lightning pains, and giving a history of syphilis ten years previously. Examination of the cerebrospinal fever revealed a lymphocytosis of 15 cells per c.mm. albumen normal. Three injections of novarsenobenzol (30, 45, 60° C.) were given at eight days' interval. Three weeks after the last injection the abdominal herpes appeared, and three weeks after the herpes an external oculo-motor paralysis of the left eye. A second examination of the cerebrospinal fever at this time revealed a lymphocytosis of 85 cells per c.mm.

With regard to the nature of this predisposition one can readily admit that the meningeal reaction, which is present more or less in the majority of syphilitic subjects (especially after the primary stage), will naturally open the road to infection by the still unknown organism of herpes zoster. In addition, an inefficient arsenical treatment might under certain circumstances accentuate, some time later, this same syphilitic meningeal reaction, and hence reinforce this predisposition to herpes zoster.

It would seem also, from the figures in Table II, that in syphilitic subjects the herpes zoster has a predilection for the lumbar and sacral ganglia, just as the lower spinal regions are more frequently attacked in syphilitic meningitis (cf. the relative frequency of tabes affecting the lower limbs and tabes affecting the upper limbs).

Conversely, in a case of herpes zoster the possibility of a prior syphilitic infection must be considered, more especially so if the herpes involves the lower spinal ganglia.

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EDITOR.

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BRAIN.

PART II, VOL. 42.

GUNSHOT WOUNDS OF THE SCALP, WITH SPECIAL REFERENCE TO THE NEUROLOGICAL SIGNS PRESENTED.

BY GEOFFREY JEFFERSON, M.S.LOND. F.R.C.S.ENG.
Assistant Surgeon, Salford Royal Hospital, Manchester, Late Captain, Royal Army Medical Corps.
Surgical Specialist attached 14th General Hospital, British Expeditionary Force.

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IT is common knowledge that, owing to the resilience of the cranial vault, it is possible for a severe blow to cause an injury of the underlying brain without an actual fracture of the calvarium occurring. It is granted that this injury may be sufficiently severe to manifest itself by definite and unequivocal clinical signs, but it is not sufficiently well known how common such cerebral contusion is. A scalp wound is usually regarded as a trivial thing with an unusually happy prognosis as regards healing, even when grossly infected. Attention has, however, been too sharply focused upon the wound of the soft parts, to the exclusion of the deeper lesion so often present and so vastly more important than the other. No class of head injury better illustrates the aphorism of Hippocrates with which Percival Pott prefaces his work on the nature and consequence of wounds and contusions of the head—"Nullum capitis vulnus contemnendum." The object of the present paper is to attempt to rescue scalp wounds from the position of contempt which they too often occupy. It is true that the brain injury is rarely of a very serious character unless the calvarium has given way and so allowed the force to continue and to act unopposedly on the hemisphere, but deaths from scalp wounds do sometimes occur. The lesser grades of brain injury are by no means the least interesting, and below will be found evidences of injury of very varying degrees of severity.

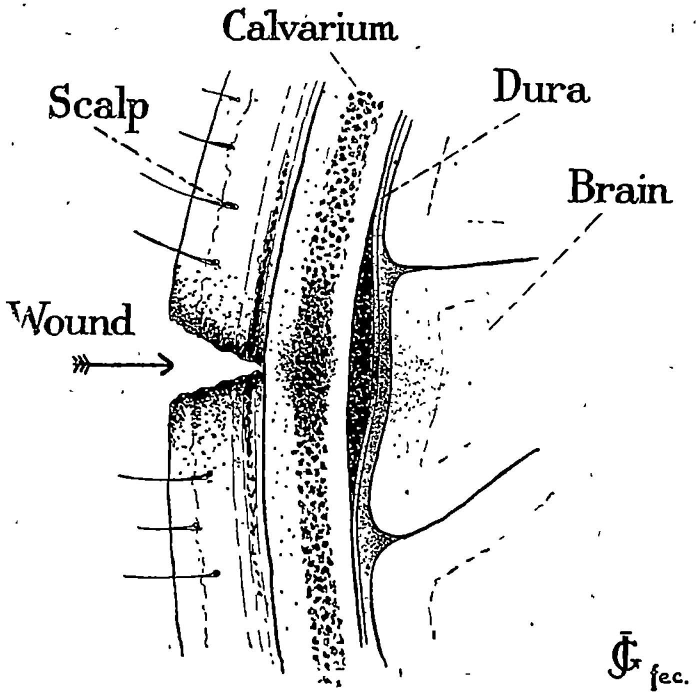

Fig. 1.—Scheme of scalp wound with intracranial injury, the calvarium being intact. Bruising of bone and dura, with small extradural and cortico-meningeal hæmorrhage.

Two factors have undoubtedly contributed to the failure to recognize intracranial upset in head injuries. In the first place the disturbance is often very slight, and in the second it wears off comparatively rapidly, frequently within a week, so that unless a neurological examination is made at once signs will be missed, and by the time these patients reach the United Kingdom all objective signs have passed away. A third factor may be added, and it is this, that the great pressure of work in France has caused most of us to confine our attention to cases more insistent in their claims, such as the penetrating wounds of the head. But that the closer investigation of scalp wounds amounts to more than a luxury, the histories set forth below will show.

The only recent references to contusion in scalp wounds are those of Adie and Wagstaffe [1] and of Harvey Cushing [2]. The former note three Jacksonian fits in 118 cases and one death (from pneumonia), the latter one death from hæmorrhage into the vermis and cerebellar fossa. Cushing, however, makes the following remark: "It is quite possible that some of the other cases in this group [scalp wounds] should not only have been trephined but should have had the dura opened as well, for eleven out of the number [i.e., 50 per cent.] showed distinct evidence of moderate intracranial damage."

In the series now to be brought forward, no less than seventeen out of fifty-four showed evidence of local contusion, and all but five a cerebral disturbance of some sort or other.

II.—MATERIAL.

The observations embodied in this paper are based upon a series of fifty-four scalp wounds under my care in the Head Service of 14 General Hospital between the months of July and November, 1918. The number of cases is admittedly very small, but they are quite unselected, some slight, some severe, and are typical of the average run of scalp wounds as seen at the base in France. A few had been operated upon before admission, but the majority were untouched. It was a general rule which admitted of no exception that all head wounds, however trivial they might appear to be, should be submitted to a rough neurological examination before operation. These remarks are the result of observations so made, often very sketchy, and jotted down under extreme pressure of work.

There can be no question but that head wounds of all degrees of severity benefit from collection into one place, where they can be kept for a long time before being moved further, and where they can receive the benefits of standardization and continuity of treatment.

III.—THE TRAUMA.

The protective value of the steel helmet is undoubtedly great, but beneath its shelter a man may receive a blow of very considerable severity without fracture of the calvarium. This is corroborated by those cases, and several were noted, where the helmet has been deeply indented without being perforated and the patient has suffered a considerable scalp wound with underlying cerebral contusion. But for the helmet, the shell fragment would undoubtedly have penetrated the head, and the case have thus passed into a graver category.

How severe the blow on the head may be is illustrated by a man who remarked several days after he had been wounded that he "could hear the old tin hat ringing still." In one or two cases the fragment has hit the helmet with such force as to break the chin-strap. This is liable to occur with bullet wounds whose trajectory is flat, whilst shrapnel bursting above tends to drive the helmet on to the head.

Notes were kept on the nature of the injury to the steel helmet as far as could be determined. Reliance had usually to be placed on the man's own statement, as not many patients succeed in getting their helmets through to the base. In conjunction with the position and extent of the scalp wound, the injury to the "tin hat" helps one to form a clearer mental picture of the exact nature of the force which has been applied, and, in my opinion, the helmets should always have accompanied the patients on their journey right through to England.

IV.—CHARACTER OF THE SCALP WOUNDS.

The wounds of the scalp were of the usual type, with contused ragged edges. They varied from one-half to four inches in length, and were from one to two days old on admission. Owing to the vascularity of the scalp, they did well with conservative excision and suture with a rubber tissue drain. The wound extended almost invariably to the pericranium, and when this was torn it was not uncommon to see a faint bruise in the bone like a shadow beneath the external table. In none of the series now under consideration was there a fracture of outer or inner table.

V.—Type of Operation performed.

Of the operative methods used little need be said here. Excision of the scalp wound as sparingly as was compatible with removal of all hopelessly contused and infected tissue was performed. The wound was then washed over with flavine followed by warm saline to remove the albuminate first formed, and then rinsed with flavine again. Catgut sutures were inserted in the galea, and the wound closed with interrupted silkworm-gut sutures, twisted twice but not knotted. A trephine disc was removed three times (see below). The anæsthetic of choice is undoubtedly novocain—adrenalin, with a hypodermic injection of omnopon $\frac{2}{3}$ gr., and scopolamine $\frac{1}{100}$ gr. an hour beforehand. The advantages are: a minimal loss of blood (and such loss may assume formidable proportions if plastic flaps have to be cut), and, secondly, the great comfort of having a conscious patient who can lie in the position most convenient to the surgeon unembarrassed by an anæsthetist. This is of especial value in wounds of the posterior part of the head. A great part of the art of surgery lies in making things easy for yourself (to paraphrase a remark of Charles Mayo's), and local anæsthesia makes this possible for the head in a way which must be surprising to any one not already conversant with its convenience.

The dura was not incised at operation either in this or in the depressed fracture series, as sepsis was already established, and it did not seem justifiable to incur the added risk which this step would have entailed. It may be noted that none seemed to be the worse for this conservatism.

VI.—Concussional Changes.

A large number of the cases showed generalized signs; a history of unconsciousness, complete or partial, with vomiting, nausea, headache, and exaggeration of the tendon jerks generally, so that one must define some standard for the diagnosis of contusion apart and aside from such signs. In the Rolandic lesions such signs can be traced through all grades of severity from a local increase of the tendon jerks and a few beats of ankle clonus on the side opposite the lesion, these being absent on the same side, up through slight aphasias, numbnesses and pareses, finally culminating in definite palsies and Jacksonian fits. In no type of cases can the effects of cerebral contusion in its varying gradations of severity be more beautifully traced.

It will be readily acknowledged that signs of contusion of the silent

areas of the brain, particularly of the frontal lobes, are very difficult to detect. It is not until the wound falls over a non-silent area, such as the motor or visual cortex, that one is able to say with accuracy whether or not the impact of the missile has caused a local lesion. These localizing signs have to be distinguished from the concussional and post-concussional effects which are met with in severe cranial injuries whatever their site.

VII.—GENERAL SIGNS.

The signs of intracranial disturbance common to all, whether concussional cases or locally contused cases, will be now discussed with a view to determining their frequence. Those cases in which a localized cerebral injury has occurred will then be dealt with.

It may be stated at once that only five patients out of the whole series showed no positive neurological signs at all. In ten more the only thing complained of was headache, but this was often so severe and the patients were mentally so dull for a short time that one could not doubt that the brain had received a severe shaking up. All the other cases presented additional and unmistakable signs which made the diagnosis sure.

Unconsciousness.—As regards a period of unconsciousness, one can here only rely on the man's statement, as it was always of short duration, and was gone by the time he reached a Casualty Clearing Station. To the patient, the border line between being stunned and being actually unconscious is indistinct. One quarter of them allege that they were actually unconscious for brief periods, whilst another quarter were stunned, frequently being knocked down by the impact of the missile.

Headache.—As might have been expected, headache has been more commonly present than any other symptom. Out of the fifty-four cases it was present in forty-five, definitely absent in six, and not noted in three. A note was kept as to its situation with a view to determining, if possible, some connexion between the site of the wound and that of the headache. It was "fixed," severest in the region underlying the wound, in twenty-three cases, roughly 45 per cent. As it improves, it tends to become frontal, and this was the commonest general site for headache. Frontal headache was present with wounds of the vertex, temporal, parietal and occipital regions indiscriminately.

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To turn now to a more detailed examination of the various contusions.

(a) *Contusions of the Motor Cortex (Thirteen Cases).*

Contusion of the motor cortex evidenced itself by motor aphasias and by palsies of all grades of severity. It was usual for the paralysis to be limited to two organs—in fact, a complete hemiplegia was never seen. In some cases the injury was very slight, and a local increase of tendon reflexes was all that was noted (see the illustrative cases below). The face and arm suffered most, and the movements of the fingers more than those of the elbow and shoulder. In fact there was an often repeated syndrome of aphasia with palsy of the right face and hand for low left Rolandic lesions, the aphasia being omitted when the blow fell on the right side. In two cases the pre-operative neurological findings were so definite that I removed a bone disc, although the cranium was quite intact. In one an extradural clot was found, in the other nothing (see Cases 6 and 10). In a third case the findings were equally definite, but this step was not taken, and I had the mortification of seeing him develop Jacksonian fits, and when a decompression was done a clot was found and washed away with no return of epilepsy (see Case 7). Jacksonian seizures occurred in three cases in all—the one just mentioned and in two others, which had already been operated upon in casualty clearing stations before admission to No. 14 General Hospital. One of these latter was completely controlled by large doses of bromide (30 gr. every two hours continued for three days). In the second recourse had to be had to lumbar puncture, and after this there was no return of convulsions. The Jacksonian fits seen in some of these head wounds, not only in scalp wounds but in depressed fractures as well, though we are not at present concerned with these last, are often of a very severe and protracted nature. In Case 9 there was hardly any interval between the second and third fit, and the twitchings continued until he was anæsthetized. In Case 7 the fit lasted for thirty-five minutes. These cases call to mind the four cases presented before the Moscow Neurological Society by Kozhevnikov under the title of "A special form of cortical epilepsy," or partial continued epilepsy. By this he meant continuous twitchings, which rose into a definite convulsion and faded again into local contractions, rising again to a convulsion, and so on without ceasing. A very pretty case was velocity projectile which has generally pierced a steel helmet before inflicting the wound.

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Case 6.—*Scalp wound over left motor and sensory cortex. Palsy right side of face and partial anæsthesia of hand of cortical origin. Cranium intact. Trephined; extradural clot discovered. Recovery.*

Lance-Corporal C. F. (Series No. 62). Rifle-bullet wound over left parietal bone September 3, 1918. Wound crosses middle of Rolando. Two clean holes drilled in steel helmet. Admitted No. 14 General Hospital, September 4, 1918. Was unconscious for a few seconds when hit, and about ten minutes afterwards felt numbness in right hand which then hung loosely at his side. Headache +, frontal; vomited twice in — Casualty Clearing Station. Nausea now, slight. Right hand numb, grip very weak; slight palsy right side of face. Tendon jerks, right side +, left normal. Radiograph, metal dust in scalp; no fracture.

September 4, 1918. Operation: Wound excised, no fracture found. In view of pre-operative neurological findings, a bone disc was removed and an extradural clot $1\frac{1}{2}$ in. in diameter discovered. Sponged away with hot saline, flavine wash. Dura not opened. Wound closed in layers with flavine cigarette drain.

September 8, 1918. Right hand improved, wound slightly septic. Bacteriologically staphylococci and long streptococcus.

September 29, 1918. Right hand still more improved, still slightly weaker than left. Face and leg normal. Subjective numbness of second, third and fourth fingers and distal half of corresponding portion of palm. Clinically appreciates cotton wool touch, pin pricks, &c., normally. Tendon jerks slightly exaggerated on both sides equally. Evening headache, slight; no giddiness. Wound healed save for two small spots.

September 30, 1918. Evacuated.

Case 7.—*Scalp wound over right motor area. Cranium intact. Jacksonian epilepsy. Trephined, extradural clot. Recovery.*

Private T. P. (Series No. 15). Bullet wound over right parietal bone, 4 in. long, crosses lower end of Rolando, August 27, 1918. Two holes in steel helmet 6 in. apart. Admitted No. 14 General Hospital, August 29, 1918. Unconscious for a few minutes after being hit. Headache ++, low frontal. Vomit 0, nausea +, palsy −; weakness left side of face; left hand grip weak; finger movements retained but slow, subjectively hand is numb and stiff. Elbow and shoulder practically unaffected. Hand was all right when first hit, but became weaker as he walked to aid post. Leg normal. No aphasia. All tendon jerks exaggerated, ++. Plantar reflexes strongly flexor. Pulse 60. Mentally clear; slightly drowsy. X-ray, no fracture detected.

August 29, 1918. Operation: Novocain-adrenalin anæsthesia. Wound excised *en masse*, bone bared, slight bruising in diploe, no fracture. Closed with flavine cigarette drain.

August 31, 1918. Neurologically no improvement.

September 1, 1918. At 6 p.m. patient had a severe Jacksonian seizure lasting thirty-five minutes. Whole of left side of body involved, but especially face and hand. Operation: Novocain-adrenalin. Wound re-opened, 1-inch bone disc removed, extradural clot found some 6 mm. thick. Bone nibbled away leaving an oval defect 3 in. long. Clot sponged away. Wound closed with flavine cigarette drain. After operation patient had the common post-epileptic paralysis of left arm.

September 2, 1918. Arm recovering; Todd's paralysis passing off. Elbow and shoulder movements normal.

September 9, 1918. No further fits; hand now quite recovered, fine movements can be executed firmly and rapidly, but not yet quite normal. Subjectively, hand is still a little numb. Face recovered.

September 17, 1918. Hand is now normal. Face, arm and leg normal. No headache, giddiness or nausea. Tendon jerks slightly exaggerated. General condition excellent. Pulse runs 64, 72, 66, 64; temperature 98° F.

October 13, 1918. Seen in England. Up and about; no headache, no giddiness; arm and face normal.

Case 8.—*Scalp wound over left parietal field. Cranium intact. Paresis right arm. Jacksonian fit. Recovered.*

Lance-Corporal J. G. (Series No. 59). Shrapnel wound over left parietal bone 2 in. from mid-line and post-Rolandic, September 2, 1918. Wound overlies middle of left parietal field. Half-inch hole in steel helmet, missile came directly from above. Complications: flesh wounds of right arm and thigh. No vomit, no nausea. Hand and arm felt numb after wounding. Unconscious −, stunned +, headache +. Scalp wound excised in — Casualty Clearing Station, September 3, 1918, together with thigh and arm wounds; no fracture of skull. (Admitted No. 14 General Hospital, September 4, 1918.) Wounds clean. On September 8, 1918, patient had a brief Jacksonian fit limited to right arm. Post-epileptic Todd's paralysis of right hand and arm; face and leg normal. Pulse 68. Put on 360 gr. of bromide every twenty-four hours.

September 11, 1918. No further fits. Bromide stopped.

September 13, 1918. Hand and whole arm still weak; has a wound on the right arm which interferes with movement and makes it difficult to judge the exact weakness due to the cerebral injury. Fingers a little clumsy at rapid co-ordinated movements, but grip becoming strong.

September 23, 1918. No further fits; hand recovered. Evacuated.

October 23, 1918. Heard from; still has headache; says the strength has not returned to his arm (hysterical relapse).

In this case there were very slight evidences of underlying cerebral injury and the Jacksonian fit came as a surprise. As it was not repeated and seemed to be held in control by the large doses of bromide given, lumbar puncture was not performed.

Case 9:—Scalp wound over right motor area. Cranium intact. Three Jacksonian fits. Lumbar puncture twice. Recovery.

Private W. H. (Series No. 80). Shrapnel wound over right parietal bone, 4 in. aside from mid-line running forwards from a level 1 in. above inion for 3½ inches. Wound just reaches motor cortex at its anterior end. September 18, 1918. One hole in steel helmet behind; missile escaped between brim and head, tearing the scalp. Wound excised in — Casualty Clearing Station; no bone injury, September 19, 1918. Admitted No. 14 General Hospital September 21, 1918. Was unconscious first half-hour, then walked over two kilometres. No headache; no vomiting; nausea at first +. Slight weakness of left hand, tendon jerks +, equal. No aphasia. Slightly drowsy. Pulse 48.

September 26, 1918.—Patient has had one Jacksonian fit during the past night and two this morning. The last fit was very severe, and of long duration (forty minutes), controlled finally with chloroform. Was very stertorous. Pulse 60, 56, 52. Lumbar puncture under novocain: 40 c.c. clear cerebrospinal fluid withdrawn, under high tension. Bromide, 360 gr. in twenty-four hours.

September 27, 1918.—Better; no further fits. Headache, frontal, ++.

September 28, 1918.—Still drowsy, but no fits; moves left arm but it is weak. Lumbar puncture: 15 c.c. clear cerebrospinal fluid withdrawn; tension still higher than normal, but less than before.

September 29, 1918.—All headache gone; less drowsy. Bromide stopped.

October 14, 1918.—Is now quite normal. Hand grip strong; no headache. Pulse runs 68, 70, 84, 80, 90.

In this case the impact of the missile was evidently greatest at the anterior end of the wound, where it reached the motor cortex, as its main part lay over the parietal field. There was no notable sensory upset.

(*b*) *Contusions of the General Sensory Cortex.*

There was one case which was particularly interesting. In the first place it is an example of the manner in which the effects of a cerebral contusion may rapidly wear off, leaving a residuum of greater chronicity, for after being hit he was hemiplegic for a time, but the leg very rapidly recovered. In the second place it shares, with Case 6, already described, the distinction of presenting very definite sensory changes, which persisted long after the palsy had recovered. It is therefore better as an example of contusion of the sensory field than of the motor area. These two cases should be considered together. The clinical picture of the second was this:—

Case 10.—*Scalp wound over left motor cortex and sensory defect. Cranium intact. Transient hemiplegia with persistent sensory defect. Trephined. No extradural clot discovered. Recovered.*

Private H. W. (Series No. 60). Sniper's bullet wound over left parietal bone, 5 in. above and 1 in. behind external auditory meatus, runs across Rolando on to pre-central gyrus.

August 29, 1918.—Admitted No. 14th General Hospital, August 30, 1918. Unconscious −, stunned +. Headache + +, "fixed." Vomit −, nausea −. When hit, temporarily lost the use of right arm and leg. Lay in a shell hole for six or seven hours, and whilst lying there power returned to leg. This happened within about half an hour. At dusk, walked about a mile to dressing station. On admission to No. 14 General Hospital hand was still quite numb, especially along the ulnar border of forearm and hand. Right hand grip was weak but not feeble; finger movements clumsy. No facial palsy; no aphasia. Tendon jerks normal; plantar reflex, flexor. Radiograph, no fracture.

August 30, 1918.—Operation under novocain and adrenalin. Wound excised; no bony injury found. In view of neurological findings, 1 in. bone disc removed. No fracture of inner table, no extradural hæmorrhage. Brain pulsating freely. Closed with flavine cigarette drain.

September 1, 1918.—Wick removed. Leg quite normal. Inner three fingers of left hand and ulnar border of arm slightly improved, but still numb. Feels cotton wool touch and pin-prick. Grip now strong.

September 7, 1918.—Numbness improved but still present; is a subjective numbness; cannot describe it properly; muscles do not feel supple enough.

September 20, 1918.—Grip now very strong; can write, but faint subjective numbness remains. Clinical tests for anæsthesia (wool, pin-prick, deep pressure) normal. Headache +, high frontal. Cranial defect is strong, concave, pulsates visibly. Tendon jerks arms absent, legs normal, ankle clonus two beats both sides.

September 22, 1918.—Evacuated.

Both this case and Case 6 presented a numbness of the ulnar portions of the hand, involving the inner three fingers. They are good examples of pseudo-radicular anæsthesia of cortical origin, and in the latter stages both exhibited what Head has called "introspective" anæsthesia. Unfortunately, rough tests only were made, but no doubt the joint sense and power of fine discrimination would have been found defective at first, had they been tested.

(*c*) *Injuries of the Visual Cortex.* (*Four cases.*)

Four examples of visual defect from cortical contusion occurred amongst these cases. The area striata occupies a comparatively sheltered position, less exposed to superficial trauma then the motor area and that for common sensibility. So that, unless there is a direct injury over the occipital pole, vision is not likely to suffer, and if the trauma is a direct one, the cranium will probably be fractured, and such cases are not being described in this series. It may be noted, however, that in my depressed fracture series, fifty-one in number, visual upset occurred in six out of nine possibles. Certainly the visual cortex is no less susceptible to trauma than the other cortical projection areas, and my first impression was that it is more so.

The concussional changes clear up rapidly; thus two had normal visual fields and normal acuity within a week (one in six days, one in seven), whilst only one had a persistent scotoma, lower quadrantic, when evacuated nineteen days after the injury. In this last case, the affected visual field had recovered to a very appreciable extent in that time.

In Case 11 outlined below, the trauma fell over both occipital poles and in his case acuity was greatly depressed without noteworthy interference with the peripheral field. A central scotoma was present at first, but it cleared up and at the end of seven days vision was normal and he could read the newspaper comfortably. When the blow falls to one side of the mid-line of the occiput, no doubt the falx cerebri exerts an influence in limiting the concussional change to the near pole of the hemisphere only.

Hine has considered these concussional changes in detail, and gives charts showing the progressive diminution of the scotoma as the contusional effects pass away.

Case 11.—*Scalp wound over left occipital lobe. Cranium intact. Severe contusion visual cortex. Lumbar puncture. Recovery.*

Private J. W. (Series No. 8). Aeroplane bomb wound left occiput, almost in mid-line from inion forward for 5 in., August 13, 1918. Sutured in — Casualty Clearing Station. No bone injury. Admitted No. 14 General Hospital August 14, 1918. Unconscious for some hours after wounding. Headache ++, fixed. Drowsy. Tendon jerks exaggerated, equal. No vomiting. Vision: Sees a white mist only; can just see people as shadows if they are between him and the window.

August 18, 1918.—Vision improving daily; can see across the ward; counts fingers correctly. Sees people to-day, but acuity depressed, for their faces are blurred. Visual fields equal and not contracted; small central scotoma.

Lumbar puncture: 20 c.c. of cerebrospinal fluid withdrawn; clear; tension normal.

August 22, 1918.—Visual fields normal; can read to-day; vision seems to have recovered completely.

October 10, 1918.—Heard from; says eyesight is bad; has severe headache and cannot sleep: "sorry to say my eyesight has improved very little"; probably a hysterical relapse.

Case 12.—*Scalp wound over left occipital lobe. Cranium intact. Hemianopsia in right field of vision. Recovered.*

Private C. N. (Series No. 73). Shell wound of scalp, 3 in. above inion and 1½ in. to left of mid-line, November 4, 1918. Wound overlies left occipital lobe. Excised widely in — Casualty Clearing Station; no bone injury. Admitted No. 14 General Hospital November 7, 1918. Widely open excised scalp wound running from mid-line 3 in. laterally. Needs a plastic operation to close wound as edges cannot be approximated. Never unconscious; no vomiting. Headache +, occasional, "fixed." Tendon reflexes exaggerated on right side; arms +; legs ++; left side normal. Pulse 56. Vision: Complete hemianopsia up to fixation point in right field of vision.

November 8, 1918.—Operation, novocain-adrenalin anæsthesia. Cushing's "Isle of Man incision" for plastic flaps. Flavine wash. Suture with flavine cigarette drain. Bone uninjured.

November 9, 1918.—Vomited once early this morning.

November 11, 1918.—Drain removed. Very dull mentally. Pulse has run 48, 56, 60, 50, 56, 56.

November 14, 1918.—Still drowsy; lumbar puncture performed; 25 c.c. clear cerebrospinal fluid withdrawn. Tension +.

November 16, 1918.—Much better and brighter.

November 23, 1918.—No headache. Tendon reflexes normal, but ankle clonus two beats, both. Vision improved; residual scotoma in right inferior quadrant slightly invading superior. Can read easily.

IX.—CONTRALATERAL CEREBRAL CONTUSION.

Evidences of contralateral cerebral contusion were noted in four cases, in all of which the motor cortex was the sufferer. In these cases there was increase of the tendon reflexes on the same side as the scalp wound, but the brain lesion was never so severe as to cause more than a numbness and slight weakness of the hand at the most, a declared palsy was never seen. A slight contralateral meningo-cortical hæmorrhage was probably present, as the disability rapidly wore off. The following is an example, and represents the mildest form which local brain contusion can take. The signs are definite enough to leave little doubt as to the actual condition present.

Case 13.—*Scalp wound over right parietal eminence Cranium intact. Contralateral injury left motor area. Recovery.*

Lance-Corporal A. M. (Series No. 63). Shell wound right parietal eminence, November 4, 1918. Admitted No. 14 General Hospital November 6, 1918. Wound is small and superficial. Never unconscious. Headache +, left parietal. No vomiting nor nausea. No palsies. Tendon reflexes, arms normal, legs ++, inclined to be clonic, right more than left. Ankle clonus four to five beats right, nil left. Pulse 64.

November 12, 1918.—Pulse 48. No headache. Right side tendon jerks (i.e., same side as head wound) more active than left; clonus six beats right side. Pulse running 64, 60, 50, 68, 48. Evacuated, United Kingdom.

November 13, 1918.—Heard from. Very well; slight giddiness only.

This was evidently an injury of the left parietal cortex by *contre-coup*, and presents evidences of a very slight contralateral injury in the form of increased tendon reflexes without a sign of paralysis.

X.—PATHOLOGICAL ANATOMY OF CEREBRAL CONTUSION.

As all of these scalp wounds recovered, one cannot say from experience exactly what the lesion was, but presumably it took the form of a slight meningo-cortical hæmorrhage. This could rarely have been large for two reasons: in the first place the palsies rapidly cleared up, which they could not have done had the cortical hæmorrhage been of any magnitude, and in the second place the cerebrospinal fluid was clear and untinged in those cases where it was withdrawn, and was not even yellow from old hæmoglobin staining, a discoloration one not infrequently finds after severe head injury. The only observations known to me which illustrate the pathological changes underlying a simple increase of tendon-reflexes and ankle clonus of cortical origin, arise out of the very interesting series of contralateral contusions associated with penetrating head wounds published by Duperié [3]. He found, at post-mortem, patches of meningo-cortical hæmorrhage in twelve cases and severer injuries in six more. No doubt a disorganization of brain substance or a severe intracranial hæmorrhage is the pathology underlying those deaths which rarely occur in scalp wounds pure and simple (Cushing, *loc. cit.*) and may occur in lesser cases. Sometimes the disturbance may amount to no more than a local œdema, or even a commotion without gross pathological change. A continuous slight cortical stimulus, which becomes subliminal under certain ill-defined circumstances of fatigue and of changes in the circulation, seems to be the cause of Kozhevnikov's syndrome.

XI.—SUMMARY.

An analysis of the neurological symptoms and signs presented by a series of fifty-four scalp wounds treated at the base in France shows how frequently such signs are present. In only five were no such evidences found. Two types of cases must be distinguished, those in which the changes are concussional and general, and those in which signs of a definite local cerebral contusion make themselves apparent. Seventeen cases of localized cerebral contusion were found in this series (31·5 per cent.), but reasons are adduced in the text for this figure being too low. Something over 40 per cent. is probably more accurate. This is a large number and the present series is too small to render dogmatic assertion permissible. But there is no doubt whatever that the neurological signs of underlying cerebral mischief in scalp wounds have been greatly neglected in the past; the eye has seen only the wound of the scalp and the mind has travelled no farther. In the majority of cases the symptoms are of a transient character and are not often very apparent (save in the case of Jacksonian seizures). Further the patients rarely associate the numbed or weak hand and the contracted visual field with the head wound and do not mention the subject spontaneously.

In none of these series was there any injury to the skull, yet there were eleven definite local contusions of the motor cortex, four of the visual, and two more in which a motor lesion was associated with a sensory disturbance of the hand. Three presented Jacksonian seizures, and three were trephined on the neurological evidence; in two, an extradural clot was found; in one, nothing abnormal. There were signs of contralateral injury by *contrecoup* in four cases.

This is sufficient to show that scalp wounds offer a definite field for neurological investigation, though scalp wounds in civil practice will probably not be so fertile a field for exploration, as the force which produces them is usually less than that of a high-velocity projectile.

There is a moral to be drawn from the above findings with respect to the assessment of pensions. It must be remembered that whilst the wound of the hairy scalp may have been in itself a trivial thing, many men may have suffered a cerebral injury of no little moment, and this must be given adequate consideration in the medical boarding of such subjects.

In conclusion, I must tender my thanks to several people: to Colonel Webb-Johnson, C.B., D.S.O., for collecting the head patients together for me and for arranging special facilities for working up the cases for publication; to Colonel Gordon Holmes, C.M.G., for his help and advice on the clinical side, and to Colonel R. J. C. Thompson, C.M.G., D.S.O., the officer commanding No. 14 General Hospital, for permission to publish these cases. Nor can I close without thanking Major C.

Mackenzie, O.B.E., and Captains R. S. Dobbin, O.B.E., and R. F. Young, M.C., who have kindly operated upon some of these patients for me.

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SOME BIOLOGICAL EFFECTS DUE TO HIGH EXPLOSIVES.

BY ALFRED CARVER, LATE CAPTAIN (T.C.), R.A.M.C.,
Director of the Birmingham Psychotherapeutic Clinic,
AND
A. DINSLEY, LIEUTENANT, R.A.O.C.

QUITE early in the course of the war the symptoms of nervous origin exhibited by a group of the soldiers who had been subjected at close range to the detonation of high explosives excited widespread interest and attention. Never before had such a mass of material been presented for investigation, but the underlying changes of the condition, then termed "shell-shock," were wholly obscure. Mott [Lettsomian Lectures, The Medical Society's *Transactions*, Vol. XXXIX, 1916] in two cases which came to autopsy described multiple punctate hæmorrhages in the substance of the brain; and the view that the condition was due to more or less gross structural damage of the central nervous system was, for a time, widely held. As time went on, experience showed such a view in its entirety and for the majority of patients at least, to be untenable, and the pendulum has gradually but steadily swung to an opposite extreme. At the present time the very term "shell-shock" is taboo, and in the Services has been replaced by the equally unsatisfactory one of "neurasthenia." This change in terminology indicates very clearly the present general attitude of workers and observers on this subject: an attitude which evokes emotional factors as the sole cause of of all neuroses, both those of peace and war. Far be it from us to deny the important influence of the emotions in such conditions, for the evidence that the emotions in many, if not in a majority of, patients play a fundamental part appears conclusive. At the same time one meets with a large number of patients suffering from the neuroses of war in which the emotional factor does not appear to be primary, and cannot be considered as causative. In such patients, therefore, a purely psychogenic explanation will not suffice. Observation of this group reveals that physical or "commotional" factors have been operative.

First one can distinguish a sub-group in which the ætiological factor is "direct concussion" produced by the impact of missiles—either fragments of shell or earth—upon the tissues overlying the central nervous system, but in which the brain, cord, and membranes have not been damaged by the missile. The existence of this group has been noted, but in this country at any rate its importance has been very largely overlooked, and the symptoms which distinguish it from the psychogenic group have not been sufficiently generally recognized or clearly perceived to ensure its acceptance as a definite type. We consider that the symptoms of "direct concussion" are distinctive, and shall refer to them in detail later on.

A second sub-group which has been discussed—mainly by the French—is that which may be termed "indirect concussion." In this, although there is no direct concussion in the ordinary sense of the word, the patient was sufficiently close to the bursting of a shell as to be subjected to the sudden violent variations in pressure which accompany the detonation of high explosives.

A third sub-group, and one to which I have failed to find any reference in the literature, is that in which the ætiological factor appears to be the fine, extremely rapid vibrations which are one of the less known products of the detonation of high explosives. These vibrations are capable of agitating the nervous system in such a way as to produce a condition clinically closely resembling that which results from excessive emotion.

If the above contentions be verified, the neuroses of war may have either a psychogenic, or a physiogenic, or a mixed ætiology.

The thesis to be put forward in this paper as a result of experiments is, that not only is the hypothesis of a purely psychogenic origin inadequate to account for all the neuroses of war, but that definitely physical factors also play an important pathogenic rôle.

Whatever be the origin of the "shock" it must be assumed to have some physical basis, just as must all normal processes, though this simple deduction seems often to have been lost sight of. As Purves Stewart has put it, "the old definition of a neurosis as a nervous disease devoid of anatomical changes is inadequate. Disease without some underlying physical basis is inconceivable. The lesion need not be visible microscopically; it may be molecular or biochemical."

As to the nature of the changes continually taking place, either in so-called "normal" or in diseased processes, practically nothing is known; yet that emotional shock does in some way, no matter how slight, modify them is generally conceded. It is not difficult then to allow that the grosser physical agitations, such as those referred to above, are likely to exert an even more profound influence upon the delicate adjustment within the nervous system. Whether this be brought about by rendering the subcortical centres more excitable, or by inhibiting the higher centres, or by any other means, the clinical picture is one of a relative inefficiency of normal cortical control.

The fact that, at first sight, the immediate syndrome in typical examples of purely emotional shock is opposed diametrically to that in the commotional group—viz., excitation as opposed to stupor or loss of consciousness—need not be interpreted as implying that the underlying physiological events differ widely either from one another or from the normal. It would seem more helpful to regard them as a matter of degree rather than of quality.

This speculation is merely offered as a suggestion, and one must frankly admit that in spite of many efforts no knowledge which can be regarded as final has been acquired in this line of investigation.

The conditions under which "shell-shock" arises in man render accurate observations extremely difficult. It, therefore, seemed advisable to carry out experiments upon animals in such a way that the weight of the explosive used could be kept constant, its nature and composition known but varied at will, the actual distance of the animal from the centre of detonation measured, and other factors also accurately taken into account.

With this object in view the experiments detailed below were undertaken.

Before setting them out, however, it will be well to consider briefly what is understood by an explosive and what are its essential properties.

An explosive may be defined as a substance capable of being suddenly transformed into hot gases, which at the moment of their formation tend to occupy a far greater volume than the original substance, and consequently exert a great pressure, in every direction, upon their immediate surroundings.

The pressure exerted by some explosives exceeds 300 tons per square inch. The amount of destruction which can be accomplished by an explosive under the most favourable circumstances is known as its "power." A rough empirical measure of this "power" is obtained by multiplying the volume of the gas produced by the heat generated in the process. The shattering or disruptive effect—"brisance"—is, however, mainly dependent upon the rapidity with which the change takes place. A slow explosion has the effect of a relatively prolonged push, a rapid one that of a sudden sharp blow as from a hammer. In the case of "high" explosives the chemical change is propagated as a wave—"the wave of detonation"—through the mass at a velocity exceeding 10,000 metres per second.

The criteria which determine whether an explosive shall be called "high" are thus the production of a great volume of hot gas in so exceedingly short a period of time as to be practically instantaneous; —the shorter this time factor the "higher" the explosive.

The force that must be transmitted to any given explosive in order to cause detonation is termed its "tonal standard." For example, if a sudden blow approximating 250 tons per square inch is required to detonate an explosive this constitutes its "tonal standard" or degree of sensitiveness.

The disruptive effect of a high explosive may be calculated by multiplying its "power" by its "velocity of detonation." When a high explosive is detonated there arises, first, a sudden terrific blow which exerts a compressing and shattering force upon its surroundings in every direction. This is instantaneous, and is immediately followed by an equally sudden decompression. Thirdly, rapid oscillatory or vibrating movements are set up, which only gradually die down. The nature of these vibrations requires further investigation, but it seems probable that in addition to the material, molecular vibrations, there arise also ethereal vibrations of somewhat the same order as those utilized in wireless telegraphy. However this may be, each of the three results just noted requires analysis when we are considering the effects of detonation upon living organisms.

Another interesting and important property of explosives is that when a wave of detonation, started at a considerable distance away, is transmitted to a second suitable source, detonation of the latter may result. Even if the distance be too great or the transmitted detonating wave, for any other reason, inadequate to excite immediate detonation in the second substance its physical state becomes altered in such a fashion as to render it more unstable; and a series of detonating waves just below the tonal standard will *eventually* cause its detonation.

The above are, briefly, some of the more essential general characteristics of high explosives. For military purposes these properties have been taken advantage of in the filling of shells, bombs and grenades in order to secure:

(1) "Fragmentation" of the container—shell or bomb—the lethal effect in this case being dependent upon the flying fragments.

(2) "Brisance" or disruptive effect due to the violence of the detonating wave.

(3) A deliberate combination of (1) and (2).

There is a further effect which will be discussed later: viz., the purely demoralizing effect which is produced by the wave of detonation outside the sphere within which it causes any demonstrable physical destruction or wounds.

Evidence will be brought forward to show that the Germans paid special attention to this peculiar effect, and arranged their shell-fillings in such a way as to enhance it.

This is fully in keeping with other of their methods of warfare, and might be described as "frightfulness by detonation."

With the obvious effects of "fragmentation" this paper does not concern itself. Attention will be directed entirely to the effects of detonation, and even here mainly to the indirect rather than to the more obvious direct effects; the latter of which will receive merely passing mention.

If a high explosive be detonated at a point X, certain zones can be mapped out around this. Three such zones may roughly be distinguished, their radii depending, amongst other things, upon the weight of explosive employed. It will perhaps be helpful to give a short general summary of the findings which lead to the establishment of these zones before entering into details of actual experiments. Zone A is delimited by the extent of obvious gross disruption, and may be termed the "zone of brisance"; within it a crater is formed, barbed wire and other obstacles are blown aside, broken and distorted; animals usually killed and lacerated; other high explosives immediately detonated.

Outside this zone is a second one, B, which must be rather more fully considered. It may be termed the "zone of decompression," for the disturbances in biological processes which take place within it seem largely attributable to this factor, though coarse jarring and shaking movements are also of importance. In zone B the gross effects of shattering and disruption are no longer evident; animals placed in it (and protected from flying fragments arising from zone A) are generally "concussed" without showing signs of any external injury; only sensitive explosive substances, whose "tonal standard" is somewhere near that of the primary explosive, detonate, and even their explosion does not invariably occur. The outer boundary of this zone cannot be sharply defined, but beyond it there can be named a zone, C, in which the effects of detonation are modified further. In zone C the effects upon animals vary considerably, but as a rule a short transitory state of stupor followed by a stage of excited confusion is witnessed. High explosives placed in zone C only detonate if they have the same tonal standard as the substance employed at X, yet if they are left in position during a series of observations the fact that their stability has been thereby diminished can easily de demonstrated experimentally. Explosives after subjection to this treatment are always dangerous and require very careful handling.

The outer margin of zone C shades off gradually.

Experiments were first carried out in water, the test animals being fish (perch). A depth charge of 6 oz. gelignite was used. Fish in zone A were rendered obviously *hors de combat*, showed gross lacerations—especially of the gills—and were sometimes torn in pieces. These findings might well have been anticipated, and may in any case be passed over as not germane to our subject.

Fish in zone B, after the detonation, floated in an almost vertical position, but slightly inclined with their ventral surfaces uppermost. At this early stage their mouths protruded just above the surface of the water, and the whole of their bodies were rigid; if the fish were pushed down to a depth of about 2 ft., they sank slowly to the bottom of the tank, and there remained. The first reflex shown by fish in this zone was erection of the dorsal fin upon stimulation of the skin to either side of it. Next there occurred spasmodic movements of the opercula and gills; these were violent and irregular. In those fish which eventually recovered, swimming movements began to be possible about half an hour after the detonation. At first the movements were only carried out in response to stimulation of the abdomen—stroking with a piece of stick—and they carried the fish only forward in a direct line; no turns were observed at this stage even when an obstruction was encountered. These first swimming movements occurred with the ventral surface uppermost, and lying almost flush with the surface of the water. Thus it can be said that up to this stage the fish had lost their power of equilibration, and with this the whole of their orientation in life.

The majority of the perch which attained the power to swim as just described gradually became more and more active, and after passing through a side uppermost position, and remaining quiescent for long pauses, they righted themselves and began to swim about in the ordinary way. In about twelve hours after the detonation, those fish which had not entirely succumbed were to all appearances completely normal.

Dissection of the dead ones showed, as a rule, hæmorrhages in the upper region of the spinal cord and medulla, congestion of the foreparts of the brain, and a number of hæmorrhagic points in the mid-brain and basal gangliar region. The gills and other viscera were congested, and often showed areas of hæmorrhage. The extent of these lesions was naturally variable.

Dissection of fish taken at random immediately after the detonation revealed either varying degrees of the above-mentioned lesions, or by macroscopic examination nothing abnormal was discovered. It is regrettable that at the time these experiments were carried out we had no facilities for preparing sections or making microscopical examinations of our material. We are, however, carrying out further experiments and making microscopical preparations, the results of which we hope to publish later.

The results of detonation towards the inner boundary of this zone would seem to be due to sudden decompression and to the rude shaking which the creatures received. Towards the outer margin of B zone and the inner region of C zone the effects upon the fish could not be sharply distinguished; the severity of the symptoms gradually diminishing (and the anatomical lesions becoming rarer) with the radius of the circle described from the centre of detonation. Fish well out in C zone swam about vigorously in a disturbed and excited manner, but though they dashed about wildly and apparently haphazardly, it was generally noticed that the movements which they made carried them away from X (the centre of detonation). A few came to the surface and splashed about; when netted, no physical abnormality could be demonstrated, and those returned to the water soon behaved in a completely normal manner.

In considering the effect upon fish of vibrations thus set up in water, one must not be unmindful of the great development in these creatures of sense organs which are directly susceptible to stimulation of this type. We refer to the pre-oral mucous canals which enable a fish deprived of its eyes to guide itself along tortuous passages by the delicate appreciation of the reflected pulses of water. Also the lateral line organ which subserves similar functions. It is, therefore, conceivable that the effects of violent vibrations may be in part due to excessive stimulation of these numerous special sense organs; the fish being, as it were, swamped by the flood of incoming impressions. If this be so, the shock, though physical, would be more accurately described as of neurogenic than of commotional origin.

Probably both factors play a part, and in any case it is impossible to discriminate between them in the experiments as carried out. It is well known that in man unconsciousness can be produced by purely reflex stimulation of the skin, of the eyes, of the ears, &c., e.g., by bastinado, by extremely bright lights, as of furnaces, and by rotation in a chair. In such cases the whole ego is swamped by an excessive flood of afferent impulses which produces a condition of neurogenic shock, there being no "commotio." We have no evidence which leads us to think that neurogenic shock, as above described, plays any appreciable rôle in the causation of the war neuroses, and shall not refer to this aspect of the subject any further.

Experiments with mammals—rats and mice—on land were carried out in the following ways: Perforated zinc cages were used, partly to fix the position of the animals and partly to protect them from flying fragments. These cages were distributed at measured distances about the point X. The charge was standardized to 3 oz. of explosive. In one series of experiments the charge was buried in a hole 6 in. deep in order to imitate a shell which penetrates the ground before detonating. In this case a major portion of the force seems to be directed conically in an upward direction and there is less lateral spread along the surface of the ground. Using 3 oz. of gelignite in this way, a crater measuring about 18 in. across was formed; the B zone extended roughly 12 in. outside this, and the C zone another 20 in. or more. That is to say, that under these conditions demonstrable results were produced at a distance of from 4 to 5 ft. around X. In a second series of experiments the charge was not earthed, but simply laid upon the surface of the ground in order to imitate a shell exploding immediately upon light contact.

In this case the crater formed was much smaller, but the force expended in a direction parallel to the surface of the ground more extensive, and the boundaries of the zones lay farther out from X. With these exceptions the results in the two series of observations were essentially the same.

In zone A cages in and immediately outside the crater formation were simply blown away and distorted, the contained animals being killed or severely wounded by direct violence. These, together with animals wounded by fragmentation or the shattering of the cages, will not be further considered. Those animals which escaped this direct trauma were invariably rendered unconscious, their eyes were bloodshot and frequently there was external hæmorrhage from the ears, nose and mouth. On dissection varying amounts and degrees of internal hæmorrhage in the viscera and central nervous system were revealed; the alveoli of the lungs were almost always found to be to a certain extent ruptured. These gross changes would seem in part attributable to the direct blow of the displaced air which strikes like a solid substance, and in part also to the effect of exceedingly rapid decompression immediately succeeding this. At the inner margin of zone B the findings, though in the main similar to those just described, were very much less in degree. When cages were shielded by a small mound of earth from the direct impact of displaced air, the animals were sometimes found to be dead even though, except for injection of the conjunctivæ, they exhibited no signs of external injury, and upon dissection the only abnormality disclosed by coarse examination was a general capillary engorgement—especially noticeable in the central nervous system and meninges.

Further out in zone B a state of stupor or transitory loss of consciousness was an almost constant result. The duration of this state varied inversely with the distance from X.

During the course of recovery twitching movements of the limbs were often present, and then the animal, if stimulated by appropriate physical agents, showed massive and exaggerated reflex reactions. For example, the application of a pin-prick to one hind limb might at this stage be followed by a bilateral flexion of the hinder extremities, or even by a generalized convulsion.

There was frequently considerable difference in the activity of the reflexes on the two sides of the body—a hemiplegic distribution; but as a rule the fore limbs were more severely affected than the hind limbs, and showed weakness, as evidenced by inco-ordination and dragging, after the latter had regained normal movement. Reflex responses, though vigorous, died away quickly, but were often succeeded by a weaker repetition even when no fresh stimulus was given. Rapid fatigue of the response on repeated stimulation was a noticeable feature.

By dissection no gross macroscopical evidence of internal injury to such animals was discovered, though in some cases there was capillary engorgement as in animals nearer X. Whether this should be taken as indication that vaso-motor changes play a part in the production of the associated phenomena we have no means of determining.

Animals left alone during the stage of recovery gradually began to behave in a manner, to them, more normal, though for a considerable time their conduct, postures, and gaits were awkward and abnormal.

The severity of these disorders varied greatly from animal to animal and consequently it was impossible to deliminate precisely, from biological observations, the borders of the several zones. In the C zone, animals crouched down and huddled themselves together whenever a detonation took place; after this state of dimininished activity, a state of apparent excitement with increased restlessness was generally observed. If, however, animals were left exposed in this position during a series of experiments they invariably crouched down as flat as possible and seemed to be in an absolutely stuperose condition. When liberated they made no efforts to run away but remained for a long time motionless in a huddled-up posture. The interpretation of these latter abnormalities in behaviour is difficult. Should "fear" be allowed as the main cause, or are other more material factors also at work?

If instead of employing, in the experiments, a single explosive substance at the point X, one detonated a composite or mixed charge—standardized to 3 oz. in every instance—all the above-mentioned effects become more pronounced. The increase of effect was particularly noticeable in the C zone and its immediate surroundings.

In this connexion it is interesting to record some observations carried out upon physically and mentally fit men of an "Ammunition Proof and Demolition Section" during the course of their ordinary duties. The staff was drawn from infantry men who had some technical knowledge. They were sheltered in a well-protected dug-out about 100 yds. distant from X, the centre of detonation. In this case X was a large crater blown in the centre of the demolition ground and contained the official maximum weight for each single destruction, viz., 200 lbs.

Presumably the men were, *for ordinary explosives*, outside the zone which has been referred to in this paper as zone C.

Although the men had some technical knowledge they did not know the nature of the various explosive fillings which were to be destroyed at any given time, and it was interesting to study the differing effects of these upon them. Single simple fillings such as T.N.T., picric acid, and tetryl, rarely caused any of the men discomfort under the conditions just described, yet when mixtures such as ammonal (British), amatol (British and German), donarit and "glückauf" (German) were detonated many of the men complained of unpleasant physical sensations, e.g., "catching in the throat," "peculiar feelings in the chest," "creepy feelings down the spine," or "weakness of the legs"; others were seen to shake violently and the rate of their pulse and respirations increased.

When separated or layered fillings of different explosives having velocities of detonation which differed considerably from one another were detonated the effects were decidedly greater and several of the men under these conditions passed into a state of stupor, which was followed in some instances by violent shakings and twitching, and in one case by vomiting.

Men thus affected were not fit for duty for the next two or three days. Moreover it was noteworthy that any man who had once manifested the more intense symptoms was subsequently less resistant. And although he was fully aware that no real danger attended the demolitions he seemed to be in a state of mental anxiety, and afterwards was more easily and readily affected by the detonations than he previously had been. To use the expression of his colleagues, "he seemed to have got a sort of respect for H.E." Now one word upon the nature of these mixed and layered fillings. Examination of certain German shells shows that layered fillings were deliberately employed, although in manufacture they involve more trouble and labour. For example, the 15-cm. howitzer shell has the top half of the filling composed of a mixture of 60 parts trinitroanisol and 40 parts ammonium nitrate. This mixture yields a detonating wave with a velocity of 4,850 metres per second. The lower half of the shell is filled with dinitrobenzene which yields a detonating wave with a velocity of 6,000 metres per second. The upper and lower charges are often separated by a diaphragm of wax or wood.

This type of filling is also found in the 25-cm. minenwerfer short-shell. As the latter has not to take the grooving of a gun-tube the container need not be strong. In practice it was made of a sort of Britannia-metal which simply pulverized on the detonation of its contents. The shell, therefore, cannot have been intended to act by "fragmentation." Captured German documents reveal the fact that this type of shell was especially intended for use immediately prior to an attack, and in sectors where the enemy were well entrenched and possessed good dug-outs. Hence it is highly probable that the Germans were aware of the peculiar demoralizing effects of these mixed and layered fillings. Reference should also be made to the German "disk-granaten," known to British troops as the "oyster-grenade," and to the "stiel-granaten" known as the "potatoe-masher"; neither of these kill by fragmentation, but both are par excellence demoralizing.

It would be interesting to know if the Germans' use of these fillings was based upon experimental findings, and if so what was the precise nature of their experiments.

Most of those who have been through a severe bombardment, either from the above-mentioned shells or from aerial bombs, can bear testimony to the peculiar demoralizing effect it had upon them, and how this state of demoralization was succeeded, owing to summation of effect, as the bombardment continued by a sort of fixed "glassy feeling," even when the shells did not explode particularly close to them. In order to eliminate as far as possible the psychic factor, which under such circumstances plays its part, it is instructive to study cases in which the effective detonation fell like a "bolt from the blue" upon individuals who were not in a state of tense expectation or fatigue at the moment of the incident. At the same time one cannot ignore the importance of the predisposing factors, which are highly complex. There is, however, as regards the type of neurosis developed, nothing distinctive about them; so far as our observations go they all seem to operate in a general way by lowering the resistance of the individual to all forms of shock.

Of all predisposing factors fatigue, both physical and mental, is undoubtedly the most important. A type of history which has attracted our attention by its frequency is that of the soldier who had been moved rapidly from one part of the front to another, and on arrival at the new sector was sent direct into the firing line. He generally says that the trenches were in bad condition, and that while exhausted on his first evening here his company were subjected to heavy bombardment. Under conditions of this sort the soldier seems particularly liable to break down either immediately or during the course of the day following.

A rest of comparatively short duration exercises a truly wonderful influence in restoring the resistive powers.

In our experience the following points are helpful in determining the nature of the primary causal factor in cases where it is doubtful.

First, to deal with cases in which "direct concussion" is the causal agent. The initial symptom is unconsciousness; often of several hours' duration, and possibly persisting for days. Consciousness when recovered does not remain clear, but the patient passes through a phase of variable length, during which he loses and regains it, the so-called "dipping of consciousness." Aphasia and sphincter troubles are common at this stage, which is frequently associated with an active delirium in which the patient re-enacts episodes of his military service. The general condition is one of extreme exhaustion: all mental processes are sluggish, and there is great difficulty of concentration. Amnesia, both for the immediate and remote past, is a common occurrence. The voice is often altered, becoming slow, monotonous, and higher pitched than is natural to the patient. In severe cases these symptoms tend to persist for many months, and relapses are easily induced by any fatigue; we have noticed them after long railway journeys, &c. Clinically the importance of recognizing these symptoms is that the prognosis in cases of genuine direct concussion is much graver than in those giving a spurious history of concussion after being thrown down or partially buried. Also psychotherapeutic treatment is of no avail, except in so far as fixation of symptoms may have supervened in the later stages.

In such cases experience shows that prolonged rest and freedom from strain of all sorts are essential.

The discrimination of cases of "indirect concussion" requires more careful study. Unconsciousness or stupor of relatively short duration is the rule, but it is often difficult to obtain an accurate history on this point, as there is a tendency on the part of the patient to exaggerate, and corroborative evidence is rarely forthcoming. The phenomenon of "dipping of consciousness" is not observed, and active delirium of the occupational type is rare. Amnesia, though frequently present, is much less in extent, is only retrograde, and is more readily recovered than in cases of direct concussion. There is a greater tendency to the superimposition of functional troubles such as paralysis and algesias. These may develop immediately, but more commonly they come on later as the symptoms of commotional origin are recovering. If they are removed by appropriate treatment, the patient after a few weeks complete rest generally "feels as well as ever." Easily induced fatigue and diminution of power to concentrate are, however, apt to be more persistent symptoms, and the patient, in spite of his statement that "he feels quite all right," should be given a more prolonged period of freedom from strain.

Cases in which the neurosis has arisen as the result of exposure to detonation in what we have termed the C zone are naturally more difficult to differentiate from those of purely psychogenic origin. The description, already given, of men so exposed in the "Ammunition Proof and Demolition Ground" affords a better picture of the onset of the neuroses than can be got from the more complicated conditions obtaining in trench warfare. One must remember that in the latter the bombardment is more incessant; the soldier in a state of expectancy, and possibly also of physical fatigue, all of which factors sensitize or predispose him to the effects of detonation.

In a rather disparaging way any shell exploding outside the A zone is commonly referred to as merely the "last straw," its influence thus tacitly being attributed to purely emotional factors.

It is, however, a "last straw" which cannot be lightly disregarded, and one is justified in maintaining that a sufficient number of such "straws" will cause the downfall even of the most robust. One should bear in mind the fact that the stability of an explosive is under such conditions diminished, and that it may eventually detonate. It is not difficult to conceive that physical processes which thus give rise to alterations, in the direction of instability, in a relatively simple chemical compound such as an explosive may in a similar way affect the far more delicate colloidal solutions contained in the central nervous system, either directly or indirectly. With cases of purely psychogenic origin, many of whom have never reached the danger zone at all, it is not our object to deal

An interesting question which does arise at this point is as to whether the two ætiological factors—emotion and commotion—may not operate together and thus confront the observer with a third group of patients in whom the origin of the neuroses is mixed. Obviously, if once the possibility of a physical origin be conceded, this question must be answered in the affirmative.

We suggest, further, that this is the most common occurrence, and that whichever be the primary cause of the instability, the patient, once sensitized, remains for a long time, perhaps always, hypersensitive to both commotional and emotional stimulation. Under war conditions a vicious circle is thus established.

From a large number of instances of real "shell-shock" as distinguished from those of "neurasthenia," the following is selected as worthy of report here, not because one example can be held as establishing any general principle but because it may be taken as a representative type of the group of patients in which the primary factor was "commotional," but in which this physical origin became overlaid, as is so common an occurrence, by emotional elements during the progress of the case.

A corporal, aged 22, went to France with the original Expeditionary Force and served through the Mons retreat, the Battle of the Marne and at Ypres with great coolness and courage. He liked military life and was particularly well adapted to fighting. In May, 1915, he was one day sitting with a companion in a trench preparing some food when a large H.E. shell detonated on the parapet almost immediately above him. His comrade was killed, but this he did not know or learn until long afterwards.

For a few moments he lost consciousness, but from the account of others this period of unconsciousness must have been brief. He then went over the top, exposed himself with apparent recklessness, and rushed about in a state of oneiric delirium shouting various orders to his men. After this incident he was sent down to the Base for a rest, but in a month he was returned to his unit to all outward appearances as "fit" as ever before. Inwardly, however, he noticed a great change in himself, and found to his great disgust that he no longer could remain calm when under shell-fire.

His anger and shame at the idea of suffering from "shell-shock"—which he considered merely a polite phrase for "wind-up"—was so great that he used much effort and managed to control himself during the next two years while he remained in France. From July, 1917, to March, 1918, he was in England training as a cadet, during which time he ceased to think of all his unpleasant experiences, and when he returned to France he went with the same feeling of confidence as he did in 1914. But to his intense disgust he discovered that close proximity to shell-fire threw him into an uncontrollable state of excitement. He began to suffer from severe discomforts in the head, and felt so sleepy that he "could hardly keep awake." It now became necessary for him to avoid, by every possible trick, the occasion of a public breakdown; this he managed to achieve.

In October, 1918, he returned home on ordinary leave; on his second day in England—i.e., as soon as he relaxed control—he fell into a state of stupor and was admitted to hospital. Here, over a period of at least two months, states of stupor alternated with paroxysms of excitement and weeping. At the present time (January, 1919) he is easily fatigued, is liable to headaches, has difficulty in concentrating his thoughts, and becomes confused in traffic.

A history of this type is by no means rare, but is met with fair frequency in the Special Neurological Military Hospitals.

No useful purpose would be served by detailing a number of other similar instances, as the above case illustrates sufficiently well the points to which we wish to direct attention.

It is desirable from every point of view that cases of this type should be separated from those in which the underlying causal factor is purely psychogenic.

One cannot remain content with any classification which is based upon an arbitrary grouping of superficially similar characteristics. Every effort should be made to discriminate between the several types upon the basis of their pathogenic origin, for both treatment and prognosis are largely determined by this.

Had our patient been seen when at the Base after the first detonation one would have been justified in describing him as an instance of "shock" of purely commotional origin, and in treating him accordingly. If, on the other hand, one had seen him for the first time, and knew nothing of his previous history, in October, 1918, one might have regarded his manifestations as of purely psychogenic origin. Experience shows, however, that psychotherapeutic treatment is of no use while acute symptoms of commotional origin are present, and even when, in mixed cases, these have subsided, the progress of the patient is as a rule much slower than in purely psychogenic cases.

Although one not infrequently meets with cases in which, apparently, a single causal factor has been operative, we maintain that a careful and unbiased study of histories in the Special Military Neurological Hospitals leads to the conclusion that the combined action of the two aetiological factors is the more common event.

It seems to us that it is the failure to recognize and allow for this combined action, and the vicious circle which warfare brings about, that has led to the prevalent tendency to regard all the cases of war neuroses as emotional in origin. Perhaps another influence, making in this direction, is the fact that in the later and chronic stages of the more severe cases the pictures presented by the two types of patient gradually approximate until clinically they become identical, or at least so appear; for the most noticeable feature of shock, no matter what its pathogenic origin, is that it leads to a diminution of "higher level" control, and in its severer forms to a state of psychasthenia which shows a tendency to pass into dementia.

Conclusions.—The neuroses of war may be brought about:—

(*a*) By the action of "purely emotional shock," which at the present time is well recognized, but whose importance tends to be over estimated.

(*b*) By the action of "purely physical shock"; a study of the mechanism of which is the main object of this contribution to the subject.

(*c*) By a combination of the two above-mentioned ætiological factors; this is the most common occurrence (and after the psycho-

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ON THE DEVELOPMENT OF THE EXTERNAL FORM OF THE HUMAN CEREBELLUM.

BY J. W. LANGELAAN.
Amsterdam.

THE great obstacle to the study of the morphology of the cerebellum lies in the nomenclature. In order to avoid misunderstanding, I propose to give first a table, containing the names of the grooves, fissures and lobes I intend to use. In choosing these names I have been as conservative as possible. I followed therefore the purely topographical method of human anatomy. This system recognises an upper and an under surface of the cerebellum and a posterior margin, where the two surfaces meet. The names of the fissures have been chosen in accordance with this orientation. I do not fancy the system will be satisfactory in general, but if it helps to avoid misunderstandings it will have performed its duty. It would be possible to invent an entirely new system of unequivocal terms to indicate the principal fissures of the human cerebellum. In the table preceding this research I shall add these new terms in brackets behind the older ones.

The general result of my research is that the human cerebellum at a certain period of its development is built up of ten lobes. Because these ten lobes comprise all the later parts of the adult cerebellum, I take them as the starting point for the division of the human cerebellum.

TABLE.

Fissura prelingualis
(1) Lobus vinculolingualis
Fissura precentralis [f. centrolingualis]
(2) Lobus centro-alaris
Fissura prelunata [f. culminocentralis]
(3) Lobus culminolunatus
Fissura superior anterior [f. declivoculminalis]
(4) Lobus declivolunatus
Fissura superior posterior [f. foliodeclivalis]
(5) Lobus foliosemilunaris
Fissura horizontalis [f. tuberofolialis]
(6) Lobus tuberosemilunaris
Fissura inferior posterior [f. pyramidotuberalis]
(7) Lobus pyramidobiventricus
Fissura inferior anterior [f. uvulapyramidalis]
(8) Lobus uvulatonsillaris
Fissura preuvularis [f. nodulo-uvularis]
(9) Lobus noduloflocculearis
Fissura prenodularis [f. nodiolonodularis]
(10) Lobus nodiolovelaris

It follows also from this research that the vermis and the hemispheres during a certain stage of development are well-defined, separate parts of the cerebellum : hence it is necessary to discriminate between the fissures belonging to the vermis and those belonging to the hemispheres. But because most fissures of vermis and hemispheres later join together, it will be sufficient to add the term "pars mediana" to the name of the fissure to indicate the vermis part, and the term "pars lateralis" to indicate the hemispherical division of the furrow.

A cerebellum of the middle of the third month forms the starting point of the description. In this stage of development, the cerebellar plate (lamina cerebelli[1]) has the form of a horseshoe, which embraces the brainstem. It is placed approximately perpendicular to the direction of the stem, so that we may describe a superior, an inferior and a lateral surface in respect of the main direction of the stem.

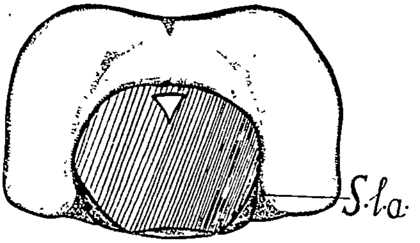

FIG. 1.—Superior surface of a cerebellum of the middle of the third month. The brainstem is cut away at the level of the cerebellar plate. *S.l.a.*; sulcus limitans ant. Enlargement × 5.

The superior surface of the cerebellar plate is nearly flat and separated by a shallow groove, the sulcus limitans cerebelli anterior, from the mesencephalon. Ventrally, the groove becomes a little deeper and broader (fig. 1). A very shallow depression, starting from the limiting groove, extends on either side over the upper surface of the cerebellar plate. Both depressions are curved towards the middle line, but in this stage of development do not yet meet there.

The superior surface passes continuously into the inferior surface. The greater part of this surface consists of a thin lamella (lamella cerebelli). Seen from the outside, it gives the impression that the lamina rapidly thins off into the lamella (fig. 2). The lamella on its posterior border is continued into the rhombencephalon. The transition of the lamella into the substance of the rhombencephalon is marked by a groove, the sulcus limitans posterior. Along the ventral border of the cerebellar plate the posterior limiting groove continuously passes over into the anterior limiting groove. The limiting groove is filled up by embryonic connective tissue, so that the true configuration of the groove is not reproduced in my drawings. The lamella cerebelli is also covered by connective tissue, which could not be removed without tearing the membrane. Several details of the lamella, e.g., the plica chorioidea, are therefore not visible.[1]

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[1] This name has been introduced by von Mihalcovics [13].

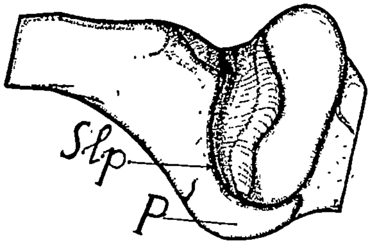

FIG. 2.—Lateral surface of a cerebellum of the middle of the third month. Same cerebellum as reproduced in fig. 1. The lamella cerebelli is covered by embryonic connective tissue, so that the plica chorioidea and several other details could not be reproduced. *P.*, pons ; *S.l.p.*, sulcus limitans post. Enlargement × 5.

The transition of the cerebellar plate into the lamella is not situated at the posterior margin of the plate, but somewhat anterior to it, so that the posterior border of the plate protrudes freely into the ventricular cavity, covered by the lamella. In fig. 2 this part of the plate may be seen shining through the lamella. This state persists during the whole development of the cerebellum and even in the adult stage, though it is less evident from the middle of the third to the middle of the fifth month.

In the middle line the cerebellar plate is thin and transparent; this transparent spot is slightly depressed on the outer surface. Whether this depression really exists or is artificially formed by the fixation, I do not know. On the inner surface the cerebellar plate rapidly thins off towards the middle line. Hence we conclude that the middle line is a place of reduced growth in comparison with the adjoining regions of the plate. This conclusion seems to tell in favour of the view that the cerebellar plate is a structure of bilateral origin (His [9]).[2] This thin and transparent place disappears *pari passu* with the enlargement of the plate, but even in a more advanced stage of the plate the region of the middle line is still slightly depressed on the inner surface.

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[1] A more detailed description of this stage has been given by me in the "Anatomischer Anzeiger" [12].

[2] A discussion of this question is to be found in O. Charnock Bradley [5].

Another thin spot exists on either side of the middle line. Here the posterior edge of the plate shows a little notch, which runs out into a shallow groove (fig. 3). By these two lateral grooves a median portion of the plate is demarcated, which later seems to form the vermis. The lateral grooves have first been observed and described by Kölliker [10].

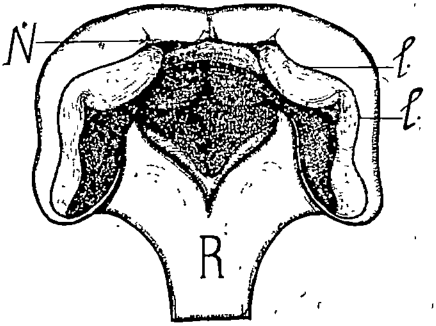

FIG. 3.—Inferior surface of a cerebellum of the middle of the third month. Same cerebellum as reproduced in figs. 1 and 2. The lamella cerebelli is torn off along the line *l*, *l*, so that the fourth ventricle is opened. The posterior border of the cerebellar plate is visible protruding into the ventricular cavity. *N*, notch in the cerebellar plate; *R*, rhombencephalon. Enlargement × 5.

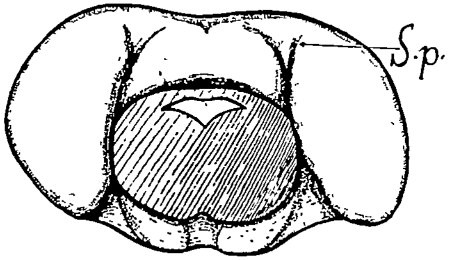

FIG. 4.—Superior surface of a cerebellum of the second half of the third month. The brainstem is cut away at the level of the cerebellar plate. *S.p.*, sulcus paramedianus. Enlargement × 5.

The next stage is somewhat older, probably the second half of the third month. In this stage, the superior surface of the cerebellar plate is more convex and more distinctly marked off from the brainstem (fig. 4). The depression starting from the sulcus limitans has developed into a shallow bifurcated groove. The medial branch of the groove curves towards the middle line, where they later join together. At the bottom of this shallow groove, the fissura superior anterior[1] makes its appearance. The field limited from behind by this groove, becomes gradually slightly elevated. In consequence of this elevation it begins to project above the regions immediately adjoining the mesencephalon. In a somewhat older stage this relation is still more accentuated (fig. 5).

The little field in front of the elevated field is triangular, resting with its base upon the tectum mesencephali. In the beginning it is indistinctly marked off from the elevated field; but somewhat later a fissure appears, the fissura prelunata, which divides the two fields. The base of the field is separated from the brain stem by a fairly deep groove, the fissura precentralis, which has partly developed from the anterior limiting groove. In the depth of this groove a small white ridge is visible, the first trace of the lingula.

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[1] "Fissura prima" of embryologists.

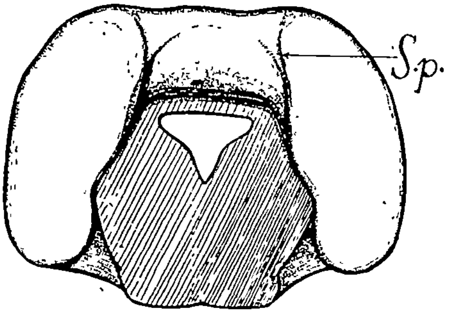

Fig. 5.—Superior surface of a cerebellum of the second half of the third month. This cerebellum is probably somewhat older than that reproduced in fig. 4. The brainstem is cut away at the level of the cerebellar plate. *S.p.*, sulcus paramedianus. Enlargement × 5.

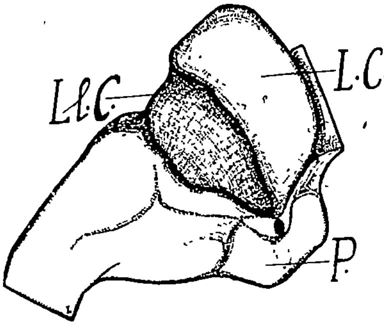

Fig. 6.—Lateral surface of the same cerebellum which is reproduced in fig. 4. The lamella cerebelli is covered by connective tissue, so that the details of the membrane could not be reproduced. *L.C.*, lamina cerebelli; *Ll.C.*, lamella cerebelli; *P*, pons. Enlargement × 5.

The lateral branch of the bifurcated groove runs in antero-posterior direction. The groove becomes flatter at this stage of development in the neighbourhood of the posterior border of the superior surface. This groove forms the origin of the sulcus paramedianus, which divides the vermis from the hemispheres. I have received the impression that the sulcus paramedianus develops from the lateral groove of Kölliker. The inferior surface has increased in size and the cerebellar plate seems to approach its completion (fig. 6). The posterior border of the plate still protrudes into the ventricular cavity, but this is no longer as evident as it was before.

The first grooves to appear upon the cerebellar surface seem to be formed by differences in growth between the regions adjoining the groove and those forming the bottom of the groove. This causes the grooves to be broad and shallow. Later, the formation of the grooves takes place by a more active process. In this case, the formation of the furrow is preceded by a proliferation of cells, in an antero-posterior direction, which is followed by the appearance of a transverse fissure, perpendicular upon the direction of the cell-proliferation. This process resembles in some respects cleavage. The sulcus paramedianus appears chiefly, if not exclusively, to be formed in the first manner, whilst the other fissures, by which the cerebellar plate is split up into ten lobes, are principally formed in the second way. Because the two processes in the beginning interfere, it is often difficult to state the exact moment at which a fissure arises. My own material tends to the conclusion, in agreement with Kölliker [10], Mihalcovics [13], Bradley [3, 4], and Bolk [2], that the furrowing begins first in the vermis, followed shortly by the cleavage of the hemispheres. The formation of the fissures in the vermis proceeds, at least in the beginning, independently of the formation of the fissures in the hemispheres. The sequence in which the fissures appear to take their origin in the vermis is: fissura precentralis, fissura superior anterior and fissura prenodularis, approximately at the same moment; next the fissura prelunata and the fissura preuvularis; lastly, the fissura inferior anterior and the fissura inferior posterior.

The hemispherical fissure, which first appears, is the pars lateralis of the fissura prenodularis, and this fissure is very soon followed by the lateral part of the fissura preuvularis. This fact is also stated by Bradley [3] for the rabbit and the pig, by Kölliker [10] for the rabbit, and in man by Smith [19], and by Stroud [22]. The fissure of the hemisphere appearing next is the pars lateralis of the fissura superior posterior. This latter furrow makes its appearance approximately simultaneously with the vermis portion of the fissuræ inferior anterior and inferior posterior. To sum up, I find, therefore, that the fissures of the vermis begin to form before those of the hemispheres; that the first fissures of the vermis arise approximately at the same time in the neighbourhood of its anterior and posterior borders. In the hemispheres, the furrowing in the neighbourhood of the posterior border precedes a little the furrowing near the anterior border.

The period of fissure formation of the cerebellar plate is only short, so that the differences in time between the moments at which the fissures appear are very small. For this reason inversions may probably occur in the sequence, by which the fissures make their appearance. Most observers, e.g., Smith [17, 19], extend the period of furrowing over several months. This opinion is probably the result of the fact that during the development of the cerebellum certain fissures may temporarily vanish and reappear.

The next stage belongs to the end of the third or the beginning of the fourth month. The superior surface shows clearly, at least in the case of the right half, the division of the cerebellum into a vermis and hemispheres (fig. 7). On the inferior surface the distinction is not yet so evident; this boundary is indicated by a shallow, partly interrupted, groove only (fig. 8).

The triangular field, which rests upon the tectum mesencephali, has considerably increased in size. It is separated from the brainstem by a deep groove, the fissura precentralis. At the bottom of this groove there lies concealed the white prominence that forms the origin of the lingula. From behind, the triangular field is bounded by a fairly deep groove, the fissura prelunata. The triangular field itself is still confined to the vermis, but shortly afterwards the furrows limiting the field extend laterally into the hemispheres. The triangular field, with its hemispherical appendices, forms the lobus centro-alaris. The median division of this lobe, i.e., the triangular field, is the later lobulus centralis.

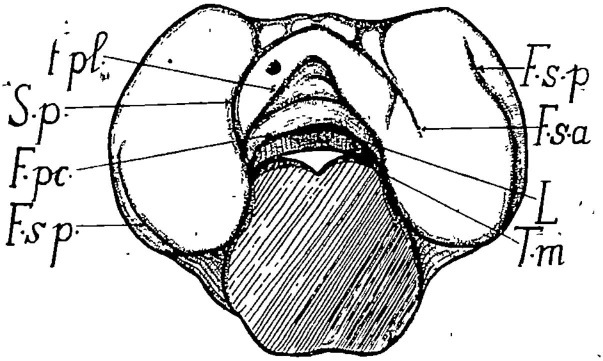

FIG. 7.--Superior surface of a cerebellum of the end of the third month or of the beginning of the fourth one. The brainstem is cut off. *F.pc.*, fissura precentralis; *F.pl.*, fissura prelunata; *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *L.*, lingula; *S.p.*, sulcus paramedianus; *T.m.*, tectum mesencephali. Enlargement × 5.

At this early stage the lobulus centralis is already divided into two parts by a complete fissure of the second order. The superior division of the lobule shows the beginning of another secondary groove (fig. 7). These grooves are the first secondary grooves of the cerebellum to appear and they precede in their appearance the primary fissures of the central region of the cerebellum.

The prominent field situated behind and above the lobulus centralis is bordered from behind by a deep fissure, the pars mediana of the fissura superior anterior. At this stage of development it is the deepest fissure of the cerebellum and easily recognizable. Originally the fissura superior anterior belongs to the vermis, but on the left this groove

penetrates through the sulcus paramedianus and begins to extend into the hemisphere. Here it remains a short groove, which does not reach the lateral hemispherical margin.

The next groove is the median part of the fissura inferior posterior. This groove belongs to the inferior surface and is at this stage strictly confined to the vermis (fig. 8). The next groove is the median part of the fissura inferior anterior, and this groove also fails to extend as yet into the hemisphere. The fissura preuvularis comes next. On the right, this groove is limited to the vermis, but on the left it already passes into the hemisphere. The hemispherical or lateral part of the fissura preuvularis arises independently, near the lateral margin of the hemisphere, grows medially and unites with the median division of the groove.

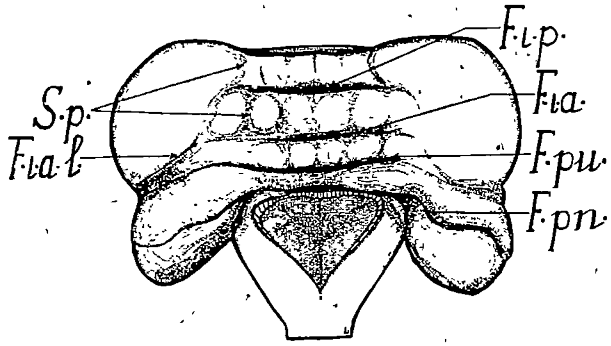

Fig. 8.—Inferior surface of a cerebellum of the end of the third month or of the beginning of the fourth one. Same cerebellum as reproduced in fig 7. *F.i.a.*, fissura inferior ant., median part; *F.i.a.l.*, fissura inferior ant., lateral part; *F.i.p.*, fissura inferior posterior. *F pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *S.p.*, sulcus paramedianus. Enlargement × 5.

The most posterior groove is the fissura prenodularis, which is also of double origin. The median part of this groove remains limited to the vermis. The lateral part takes its origin close to the lateral margin of the hemisphere, extends medially and then joins the median division in the neighbourhood of the sulcus paramedianus. Both divisions of this groove may arise at the same moment, but more often the median part precedes by a little the hemispherical part.

The last groove of this stage is the fissura superior posterior. This groove originates on the inferior surface of the hemisphere near the lateral border (fig. 9); growing medially, it reaches the superior surface (fig. 7). At the moment of its appearance this groove is not yet represented in the vermis, so that it forms the type of a purely hemi-

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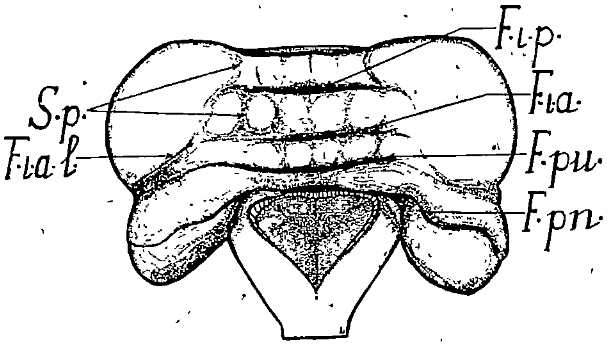

FIG. 8.—Inferior surface of a cerebellum of the end of the third month or of the beginning of the fourth one. Same cerebellum as reproduced in fig 7. *F.i.a.*, fissura inferior ant., median part; *F.i.a.l.*, fissura inferior ant., lateral part; *F.i.p.*, fissura inferior posterior. *F pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *S.p.*, sulcus paramedianus. Enlargement × 5.

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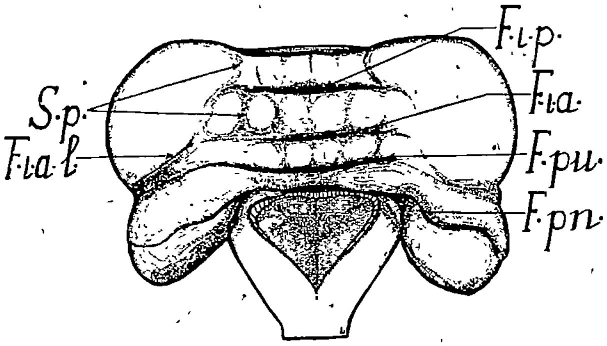

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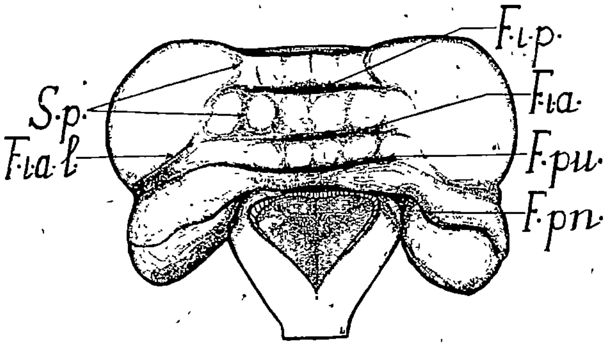

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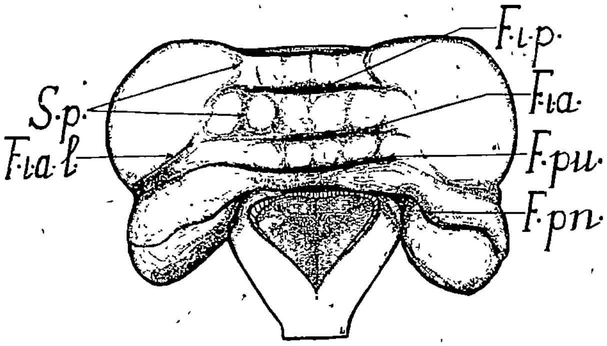

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The first lobe is the lobus vinculolingualis. This lobe lies entirely concealed in the depth of the fissura precentralis. In an earlier stage (fig. 7) it is still visible from the outside, but by the increasing rolling inwards of the anterior border it disappears in the depth of the precentral groove. There it forms a small white tongue, which rests upon that part of the tectum mesencephali which later becomes the anterior medullary velum. Laterally, the lingula falls away to the bottom of the groove. These lateral portions of the lingula form the vincula, but a distinct limit between these parts is not yet visible.

The lobus centro-alaris is the second lobe of the cerebellum. This lobe is partly overarched by the lobus culminolunatus, in consequence of the rolling inwards of the border of the cerebellum. The anterior surface of the lobus centro-alaris rests upon the lingula and the tectum, separated from these structures by the fissura precentralis. The posterior surface rests against the lobus culminolunatus, separated from it by the fissura prelunata. In the stage represented by fig. 12 the last traces of focal differentiation still linger. This enables us to state that the lobulus centralis is the vermis portion of the lobus centro-alaris. The sulcus paramedianus is faintly visible only, forming the limit between the lobulus centralis and the alæ. By a deep secondary groove the lobe is divided into an anterior and a posterior section, of which the posterior section is the larger one. This latter lobule is in its turn subdivided by another secondary groove.

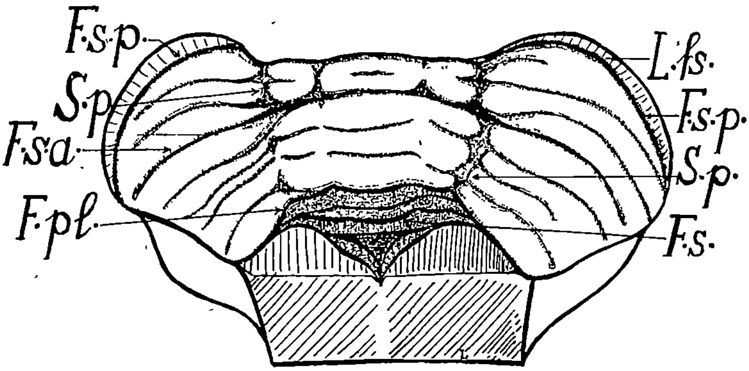

FIG. 12.—Superior surface of a cerebellum of the first half of the fourth month. Same cerebellum as reproduced in figs. 10 and 11. *F.pl.*, fissura prelunata; *F.s.*, fissura secundaria; *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *L.fs.*, lobus foliosemilunaris.; *S.p.*, sulcus paramedianus. Enlargement × 7.

The lobus culminolunatus is the third lobe of the cerebellum. The anterior surface of this lobe rests upon the lobulus centralis and the alæ. With its posterior surface the lobe is turned towards the lobus declivolunatus. Here the fissura superior anterior forms the division between the two lobes. The foci are still perceptible and also the sulcus paramedianus, at least in the left half. On the right, this groove begins to disappear. By the sulci paramediani, the lobe is divided into a vermis portion, the culmen, and two hemispherical parts. In a later stage, when the sulci paramediani have greatly disappeared, the distinction between the vermis and the hemispheres is no longer so evident. Hence, in the adult form this lobe is usually considered to form an entity, the lobulus lunatus anterior (Kölliker). Nevertheless, the discrimination between a vermis portion, the culmen, and a hemispherical section, remains of fundamental interest, independent of the fact that the delimitation between those parts may vanish externally.

If in this stage of development we open the fissura superior anterior, we see at the bottom of this groove lamellæ arising from the posterior surface of the lobus culminolunatus. These lamellæ reach the surface successively, and displace the fissura superior anterior backwards. When this process takes place very actively, it is often difficult, or even impossible, to recognise the original primary fissure. This fact may in a later stage of development cause difficulty in the recognising of the primary fissures, but it is obvious that it does not invalidate the principle of the division of the cerebellum into ten lobes by transversal grooves. The posterior surface of the lobus culminolunatus remains for a long while a centre for the expansion of the cerebellar surface. This process of expansion often proceeds asymmetrically and it also happens that a lamella reaches the surface in the hemisphere, while in the vermis it remains concealed in the depth of the fissure. This is more particularly the case with the lamellæ to be formed last. In fig. 12 an instance of this kind is reproduced on the right.

The fourth lobe in the series is the lobus declivolunatus. The anterior surface of this lobe rests against the lobus culminolunatus, the posterior surface rests against the lobus foliosemilunaris. From this latter lobe it is separated by the fissura superior posterior. This groove extends into the hemisphere as far as the lateral margin (fig. 11). It is the hemispherical boundary groove between the lobuli lunati, which lie in front, and the lobuli semilunares, which lie behind. The fissura superior anterior, on the contrary, extends only for a short distance into the hemisphere, extending no further laterally than the secondary grooves. The fissura superior anterior may, therefore, be a groove of fundamental interest in the vermis, dividing an anterior from a posterior section (Bradley [3, 4], Bolk [2]), but in the hemisphere this rôle falls to the fissura superior posterior. This relation also reflects the temporary independence of the vermis and the hemispheres.

The division into vermis and hemispheres by the sulci paramediani is still very definite in the lobus declivolunatus, and whilst the three foci of the vermis are also obvious. A secondary groove, which is not yet completed, divides the lobe into an anterior and a posterior section. This secondary groove appears first in the hemispheres, and a little later in the central focus of the vermis. During the whole course of its development the lobus declivolunatus is the most conservative part of the cerebellum. Consequently, it forms in the adult stage the part with the simplest configuration. Bolk [2] arrived at a similar result from his studies in comparative anatomy, and proposed the name of lobulus simplex. The close relationship, however, between this and the preceding lobe, especially of the hemispherical section, seems to render it desirable to retain the old name of lobulus lunatus posterior. In connection with the statements and the scheme of Bolk, the fact is worth noticing that the lobus declivolunatus shows clearly in this stage of development the distinction between vermis and hemispheres. Hence the view of this author, that the lobulus simplex would be devoid of a vermis portion, is erroneous.

If we consider the superior surface of the cerebellum as a whole, we are struck by the fact that the vermis forms such a considerable part of it. Later, during the further stages of development, the vermis remains behind in its expansion, and the hemispheres become more and more predominant.

The fifth lobe is the lobus foliosemilunaris. This lobe borders from behind on the fissura horizontalis. In the specimen reproduced in figs. 10 and 11, this fissure is not yet completed, but in other objects of approximately the same age the furrow is completed. Hence I cannot agree with Smith [19], who believes that it is not until the end of the fifth or the beginning of the sixth month that the fissura horizontalis makes its appearance.

The vermis part of the fifth lobe, the folium, in this stage of development still forms an element of the external surface. Later, however, it gradually remains behind and is in many cases overgrown by the adjacent parts, and especially by the lamellæ of the tuber. The folium is the last differentiated section of the vermis and, in the adult stage, the most reduced one. It is, like the other sections of the vermis, originally built up of four foci, but the focal differentiation appears to be transient and to disappear early. Slight displacements may occur in this region between the folium and the adjacent parts of the hemispheres, caused by difference in the rates of expansion of the surface. In consequence of these displacements the endings of the fissura horizontalis and the furrow that separates the folium from the tuber no longer coincide. In this way the different varieties arise, which are met with in the adult in this region. The region of the folium is last differentiated and for this reason it is the most variable part of the human cerebellum.

The hemispherical section of the lobus foliosemilunaris, the lobulus semilunaris superior, is not yet split up by secondary grooves. These grooves appear comparatively late, not before the middle or the end of the fifth month.

The lobus tuberosemilunaris is the sixth lobe. It is separated from the lobus pyramidobiventricus by the fissura inferior posterior. The vermis section of the lobe is subdivided into three parts. The median part, which is by far the largest, takes its origin from the central focus. Later, it develops into the tuber. Both the lateral parts are derived from the lateral foci. These parts remain behind in development, but until the middle of the fourth month they are distinctly separated elements of the vermis. In a later stage, these little fields disappear in the depth of the fissura inferior posterior and there form the small white stalks that unite the tuber with the foremost lamellæ of the lobulus semilunaris inferior. The tuber differs, therefore, in so far from the other lobules of the vermis that it takes its origin only from the central focus.

The two lobuli semilunares give the impression of forming an entity, which is at a comparatively late stage subdivided by the fissura horizontalis. The surface expansion of the lobuli semilunares begins at a very early stage and is most definite in the inferior lobule. In consequence of the considerable development of these lobules, the lateral division of the fissura inferior posterior no longer runs transversally, but bends off a little backwards. In later stages, when the lobuli semilunares prevail still more, the backward inclination of the furrow becomes more accentuated. The excessive expansion of the lobuli semilunares dominates the whole development of the cerebellum, and produces, together with the enormous development of the tonsillæ, the anomalous appearance of the human cerebellum.

The seventh lobe is the lobus pyramidobiventricus. This is separated from the preceding one by the fissura inferior posterior, and from the lobus uvulatonsillaris by the fissura inferior anterior. The vermis section of this lobe is strongly developed, and still shows in the stage represented in fig. 10 four foci. In another object of approximately the same age the medial foci partly coalesce. The focal differentiation is sharply marked in the pyramis, and it is here that the foci persist longest. The hemispherical part of the lobe, the later lobulus biventer, is narrow, in consequence of the compression exerted by the posterior border of the lobulus semilunaris. Towards the lateral margin of the hemisphere, the lobule grows broader and its surface more convex, so that it appears there as a well-marked part of the lateral surface of the cerebellum (fig. 11).

The hemispherical region immediately adjoining the vermis gives the impression of being differentiated into a focus (fig. 10, on the left). The oblong form of this focus appears to be caused by the compression brought to bear by the posterior border of the lobulus semilunaris, for in an earlier stage this focus is more rounded (fig. 8). In a later stage of development, this focus is overgrown by the adjacent parts of the hemisphere and lies at the bottom of the fissura inferior anterior. There it develops into the white stalk, by which the pyramis is united with the lamellæ of the lobulus biventer. Between the hemispherical focus and the lateral focus of the vermis lies a slightly depressed triangular field, with its base turned towards the fissura inferior anterior. This little field, which is of considerable size when the hemispherical focus is reduced (fig. 10, on right), gives origin, so far as I can see, to the area perforata parapyramidalis of Ziehen [23]. The rest of the hemispherical part of the lobus pyramidobiventricus shows no trace of focal differentiation.

The lobus uvulatonsillaris is the eighth lobe. This lobe is limited by the fissura inferior anterior on one side, and by the fissura preuvularis on the other. This latter groove is a fairly deep furrow, which near the lateral border of the hemisphere grows broad and shallow (fig. 11). In its general features this lobe resembles the preceding one. The vermis part, which still shows four distinct foci, develops into the uvula. The hemispherical part of the lobe is compressed by the lobulus semilunaris, in the same way as the lateral division of the lobus pyramidobiventricus. The region of the hemisphere adjacent to the uvula is focally differentiated. The focus gives the impression of being double; later, it develops into the tonsilla. In the human cerebellum, therefore, the uvula and the tonsilla are originally contiguous parts, belonging to the same lobe and only separated from each other by the sulcus paramedianus. For this reason I cannot agree with Smith [19], who believes that the connexion between uvula and tonsilla is a secondary one only.

The next lobe, the ninth, is the lobus noduloflocculаris. This is separated from the tenth by the fissura prenodularis. In the stage represented by figs. 10 and 11 it is a well-developed lobe, but very soon it remains behind in development, especially the more medial part of the hemispherical section.

The more lateral part of the hemispherical section differentiates further and gives rise to the flocculus. In consequence of the rolling inwards of the posterior border of the cerebellum, the vermis and the parts adjacent to it are turned towards the fourth ventricle. Hence, the greater part of the nodulus is no longer directly visible. The focal differentiation of the nodulus is only faintly indicated, but the lines of demarcation formed on the sides by the sulci paramediani are clearly defined.

The last lobe is the lobus nodiolovelaris. This lobe had already been recognised by Kölliker [10] as a separate division of the cerebellum, to which he applied the term of "gyrus chorioideus posterior." It is a well-developed lobe, of which the vermis and the adjacent parts of the hemispheres are entirely reversed. From behind, this lobe is continued into the posterior medullary velum. The transition of the velum into the substance of the lobe lies in the central region, not on the posterior border, but a little to the front, so that the nodiolus and the adjoining parts of the hemisphere are covered by the velum.

The nodiolus forms the hindmost section of the nodulus, from which it is separated by the median part of the fissura prenodularis. On the side, the nodiolus is delimited by the sulci paramediani. The wall of the hemispherical section of the lobe atrophies for a great deal in the course of development and is assimilated to the velum. For that reason, I choose the name of lobus nodiolovelaris for this last lobe of the cerebellum.

The next stage is derived from an embryo of the end of the fourth month. At that time the focal differentiation of the superior surface has entirely disappeared and only the last traces of the sulci paramediani are visible (fig 13). The hemispheres have considerably increased their surface and embrace the brainstem. By the change in the form of the superior surface, the course of the fissures is altered. Instead of running transversely they now curve forwards in the hemispheres in agreement with the form of the cerebellum.

The lingula is still small and concealed in the depth of the fissura precentralis. The central lobe forms at this stage the bottom of a niche, enclosed from the side and above by the lobus culminolunatus. This lobe assumes more and more the form of a crescent. By the disappearance of the sulci paramediani, the limit between the vermis and the hemispheres vanishes, and from that moment the lobe gives the impression of being an entity, the lobulus lunatus anterior of descriptive anatomy. In the same way the lobus declivolunatus is transformed into the lobus lunatus posterior. This lobe shows on the right the formation of a secondary groove in the substance of the hemisphere, independent of the existing grooves. At the bottom of this secondary groove lamellæ are formed, which later emerge on the surface.

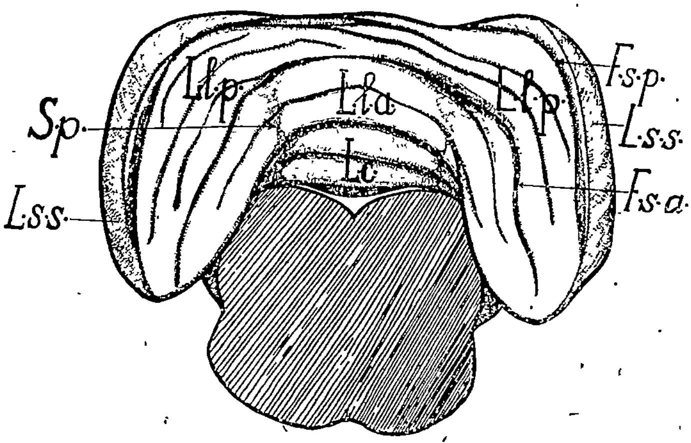

FIG. 13.—Superior surface of a cerebellum of the end of the fourth month. *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *L.c.*, lobulus centralis; *L.l.a.*, lobulus lunatus ant.; *L.l p.* lobulus lunatus post.; *L.s.s.*, lobulus semilunaris superior. *S.p.*, sulcus paramedianus. Enlargement × 5.

The lobulus lunatus posterior is limited from behind by the fissura superior posterior. This fissure forms a deep groove, which near the lateral margin of the hemisphere flattens and passes over into that part of the fissura precentralis that separates the hemispheres from the brainstem (fig. 15). In this manner a part of the forelip is formed of the fissura transversa.

The inferior surface of the cerebellum seems in many respects more conservative than the superior one. The chief changes are caused by the increase of the lobulus semilunaris. By the great increase in size of this lobe, the lobulus semilunaris superior begins to embrace the lobulus lunatus posterior from aside (fig. 13). In this way the lobulus semilunaris superior reaches the upper surface, of which it now forms the lateral border. Consequently, the fissura superior posterior is displaced forwards and ceases to be the limit between the superior and the inferior surfaces. This process gradually proceeds in the same direction, until in the course of the sixth month approximately the whole lobulus semilunaris superior forms part of the upper surface. At that moment the fissura horizontalis becomes the limit between the superior and the inferior surfaces of the cerebellum. The displacement of the fissura superior posterior is often overlooked and it was Stroud [22] and Bolk [2] who clearly recognized this fact.

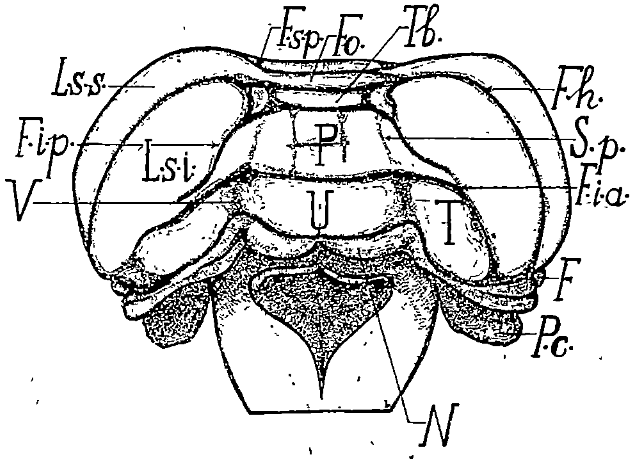

FIG. 14.—Inferior surface of a cerebellum of the end of the fourth month. Same cerebellum as reproduced in fig. 13. *F.*, flocculus ; *F h.*, fissura horizontalis ; *F.i.a.*, fissura inferior ant ; *F i.p.*, fissura inferior post. ; *Fo* , folium ; *F s.p.*, fissura superior post. ; *L.s.i.*, lobulus semilunaris inferior ; *L.s.s.*, lobulus semilunaris superior ; *N.*, nodulus ; *P.*, pyramis ; *P.c.*, plexus chorioideus ; *S.p.*, sulcus paramedianus ; *T.*, tonsilla ; *Tb.*, tuber ; *U.*, uvula ; *V*, vallecula. Enlargement × 5.

The lobulus semilunaris inferior still further increases in size and compresses more and more the lateral division of the lobus pyramido-biventricus. The fissura inferior posterior approaches thereby the fissura inferior anterior, while at the same time the more lateral part of the groove becomes flattened and disappears (fig. 14). Finally, in a somewhat older stage than that reproduced in fig. 14, the fissura inferior posterior may unite with the fissura inferior anterior. This state is nearly attained on the right side of fig. 14. By the disappearance of the fissura inferior posterior, the impression is conveyed that the lateral part of the lobus pyramidobiventricus, i.e., the lobulus biventer, has vanished. Later, however, the fissura inferior posterior reappears (cf. fig. 18). As far as I can see, the disappearance of the more lateral part of the fissura inferior posterior is a normal phenomenon, which always occurs in this stage of development. The union, however, of this fissure with the fissura inferior anterior seems not so constant and in that respect there may even be differences between the right and the left half of the same cerebellum.

The folium, which joins together the two lobuli semilunares superiores, begins to remain behind in its development and in some specimens of approximately the same age it already lies a little below the level of the adjacent parts of the vermis. The tuber, on the contrary, has greatly increased in size, especially in a transverse direction. The small flat fields beside the tuber, which derive from the lateral foci of the vermis, are partly overgrown and begin to disappear from the surface. Later, they form the little white stalks that unite the tuber with the lobuli semilunares inferiores.

In the pyramis the last traces of focal differentiation persist, and this makes it possible to state that the little field, limited laterally by the rest of the fissura inferior posterior, is chiefly composed by the hemispherical focus. The pyramis and the hemispherical foci still lie on the same level, but later the hemispherical foci disappear in the depth of the fissura inferior anterior, where they form the white stalks that unite the pyramis with the lobuli biventeres. In the case of the pyramis it is quite evident that the white stalks derive from the hemispherical foci and one would expect this to be also the case with the stalks uniting tuber and lobulus semilunaris. As far as my material goes, however, the stalks of the tuber seem to proceed from the lateral foci of the vermis.

The lobus uvulatonsillaris is at this stage of development no more a transverse lamella. In consequence of the expansion of the lobulus semilunaris, the tonsilla is displaced and the rest of the hemispherical division of the lobe strongly compressed. The tonsilla now forms an obtuse angle with the uvula and the region between these structures is depressed (fig. 14). This depressed area forms the first origin of the valecula, and because the sulcus paramedianus lies at the bottom of the depression we may say that the valecula arises in the situation of that sulcus. Under the influence of the compression exerted by the lobulus semilunaris inferior, the more lateral part of the hemispherical division of the lobus uvulatonsillaris atrophies, with the exception of a little well-marked field adjoining the margin of the hemisphere in front of the flocculus (fig. 15). This little field is variable in form and size in different specimens, but it always persists as a distinctly limited and slightly convex area till the sixth or seventh month, or perhaps still longer. This little field, which arises from the most lateral part of the hemispherical division of the lobus uvulatonsillaris, is in my opinion the homologue of the paraflocculus of Smith, the ventral part of the paraflocculus of Bradley and the pars tonsillaris of the formatio vermicularis of Bolk.

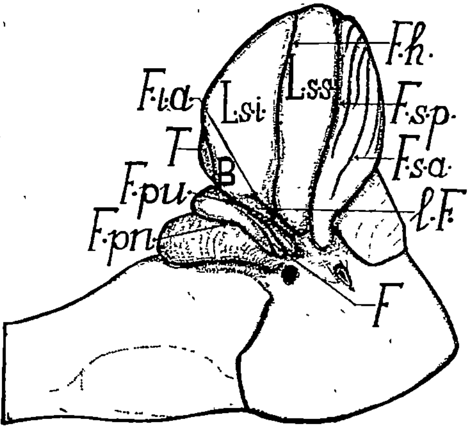

Fig. 15.—Lateral surface of a cerebellum of the end of the fourth month. Same cerebellum as reproduced in figs. 13 and 14. *B.*, lobulus biventer; *F.*, flocculus; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant.; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *l.F.*, lateral field; *L.s.i.*, lobulus semilunaris inferior; *L.s.s.*, lobulus semilunaris superior; *T.*, tonsilla. Enlargement × 5.

The fissura inferior anterior, which forms the front border of the lobus uvulatonsillaris, is in its vermis portion a fairly deep groove. In the hemisphere the groove flattens in the neighbourhood of the lateral pole of the tonsilla. Near the margin of the hemisphere, where it forms the anterior limit of the little lateral field, the groove is again well defined.

The lobus nodulofloccularis has to a great extent disappeared from the surface by the rolling inwards of the posterior border of the cerebellum. Only a small strip is visible, which is partly overarched by the posterior border of the lobus uvulatonsillaris. From this lobe it is separated by the fissura preuvularis. This groove is deep in the vermis, flattens in the hemisphere, in consequence of the incipient atrophy of the wall of the lobe, and again grows deeper near the lateral margin of the hemisphere; there it borders the flocculus in front. The fissura prenodularis forms the posterior limit of the lobe. This groove is well marked, though not very deep in the hemisphere.

The lobus noduloflocculαris can only be exposed to view by rolling the posterior border of the cerebellum outwards. This I have done in a somewhat older specimen. The embryo from which this cerebellum came was about four months old, or perhaps slightly older. Fig. 16 is the reproduction of the preparation. The vermis part is well developed and laterally bordered by the last traces of the sulci paramediani. The lobe is divided by a secondary groove into an anterior and a posterior division. The first trace of this groove is represented in fig. 10, on the right, and in the stage of fig. 14 the groove approaches its completion. Later, the hemispherical division of the groove disappears in consequence of the atrophy of this part of the lobe.

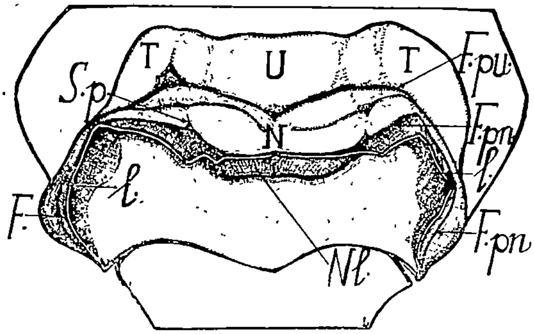

FIG 16.—Posterior border of a cerebellum of an embryo of about four months old. *F.*, flocculus; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *l.*, line along which the medullary velum is torn off; *N.*, nodulus; *N.l.*, nodiolus; *S.p.*, sulcus paramedianus; *T.*, tonsilla; *U.*, uvula. Enlargement × 5.

The most lateral part, however, of the lobus noduloflocculαris does not share the atrophy of the rest of the hemispherical division, but develops into the flocculus. In the stage represented in fig. 11, this part of the lobe is only a narrow band, bordered in front by the shallow extremity of the fissura preuvularis. Gradually this part increases in size and forms a club-like lobule, by which the shallow groove is partly filled up. The continuation of the secondary groove extends into this lobule and divides the head of the club into two parts. Very early a short lamella is formed in the depth of the fissura preuvularis, emanating from the anterior surface of the flocculus. This lamella soon reaches the surface and from that moment the flocculus is composed of three short lamellæ, which are continued medially into a broad white stalk. This stalk gradually thins off in consequence of the proceeding atrophy of the middle division of the hemispherical part of the lobe. By the atrophy of this part of the lobe, the fissura preuvularis and prenodularis vanish, with the exception of those parts that limit the flocculus. Medially from the flocculus and in the neighbourhood of the lateral pole of the tonsilla, the two grooves often become confluent and may join the fissura inferior anterior, which also begins to flatten in this region. The atrophied part of the lobe is assimilated to the medullary velum and at that moment the stalk of the flocculus seems to arise in the velum. The degree reached by the atrophy of the lobus nodulofloccularis varies in different specimens, and it is this variability that explains the differences in the form and the relations of the flocculus and its stalk to the surrounding parts in the adult.

The lobus nodiolovelaris increases in size, especially the hemisperical division; this is accompanied by a progressive atrophy of the wall of the lobe, which is gradually transformed into the plexus chorioideus. In the preparation reproduced in fig. 16, I roughly removed the plexus and the atrophied part of the velum. What remains of the lobe is the non-atrophied part. The line along which the plexus and the velum are torn off runs over the external surface of the vermis approaching the fissura prenodularis (fig. 16). In a later stage this line reaches the fissura prenodularis at the lateral border of the vermis, and is there continued along the bottom of the groove. The transition of the cerebellar plate into the velum lies, therefore, in the region of the vermis, not at the posterior margin of the plate, but a little more to the anterior, as already described. Hence the statement of Ziehen [23] that in the adult stage the nodiolus lies intra-velar, covered by the two sheets of the velum, seems erroneous to me, for the velum at the place of transition does not form a duplicature, nor is the velum built up by two distinct sheets.

In the beginning and also during the first half of the fifth month, the further expansion and development of the lobulus semilunaris is the dominating fact. This lobule, considered as a whole, becomes more convex and more distinctly marked off, especially along its lateral border. In the meantime, the lateral division of the fissura inferior posterior reappears. The first trace of the groove emanates from the still existing branch, but very soon the groove arises, also in the middle of the hemisphere, extending towards the lateral border (fig. 17). At the end of the fifth month or the beginning of the sixth, the groove is completed [figs. 18 and 19]. With the reappearance of the fissure, the lobulus biventer is again split off from the lobulus semilunaris inferior. Hence by the reconstruction of the fissura inferior posterior the original state is restored.

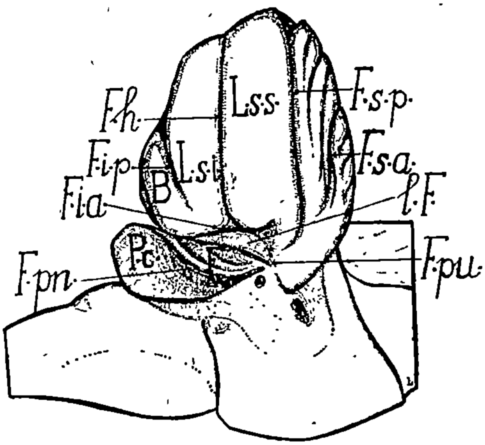

FIG. 17.—Lateral surface of a cerebellum of the first half of the fifth month. *B.*, lobulus biventer; *F.*, flocculus; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant.; *F.i.p.*, fissura inferior post.; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *l.F.*, lateral field; *L.s.i.*, lobulus semilunaris inferior; *L.s.s.*, lobulus semilunaris superior; *P.c.*, plexus chorioideus. Enlargement × 5.

In consequence of the compression exerted by the expanding lobulus semilunaris, the lateral field belonging to the lobulus uvulatonsillaris has lost its connexion with the rest of the lobe. Laterally from the tonsilla, the fissura inferior anterior has joined the fissura preuvularis as represented in fig. 18, on the left. On the right there still exists a small strip uniting the tonsilla with the lateral field. The little field itself may further increase in size, but very soon lags behind and slowly disappears as a separate field.

The atrophy of the lobus noduloflocculari proceeds further during the first half of the fifth month, and the hindmost lamella of the flocculus shares the regression of the lobe. The two other lamellæ, on the contrary, increase in size, so as to give the impression as if the flocculus were composed by only two lamellæ.

The next stage belongs to an embryo at the end of the fifth month. The changes in the superior surface are not very considerable. This part of the cerebellum continues to develop in the same direction as that already described. The rolling inwards of the anterior border has a little advanced, and the arching of the middle region, the vermis of descriptive anatomy, is also more evident.

On the inferior surface the regression of the folium and the further development of the tuber and the pyramis are the most striking features (fig. 18). The little fields between the tuber and the lobulus semilunaris inferior have disappeared from the surface. They begin to assume the form of narrow white bridges uniting the tuber with the lobulus semilunaris. The pyramis has strongly increased in size and shows a new set of secondary grooves. In this specimen the last traces of focal differentiation persist in the pyramis, but in most specimens of the same age the focal differentiation has already entirely disappeared. It seems evident in this specimen that the transverse dimension of the tuber agrees with the dimension of the median focus of the pyramis, so that this also speaks in favour of the view that the tuber is the derivative of the median focus only.

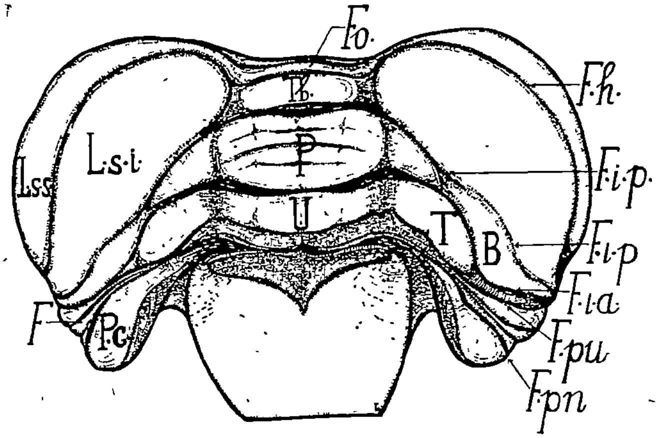

FIG. 18.—Inferior surface of a cerebellum of the end of the fifth month. *B.*, lobulus biventer; *F.*, flocculus; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant.; *F.i.p.*, fissura inferior post; *Fo.*, folium; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *L.s.i.*, lobulus semilunaris inferior; *L.s.s*, lobulus semilunaris superior; *P.*, pyramis; *P.c.*, plexus chorioideus; *T.*, tonsilla; *Tb.*, tuber; *U.*, uvula. Enlargement × 5.

The hemispherical foci of the lobus pyramidobiventricus have developed into well limited triangular fields, which form the union between the pyramis and the lobulus biventer. They still lie on the surface of the cerebellum, but by the formation of the vallecula they disappear from the surface, forming an element of the bottom of this depression. There they persist, even in the adult stage, as the white stalks uniting the pyramis with the lobulus biventer, and as the little fields described by Ziehen as the "areæ perforatæ para-pyramidales." By the reconstruction of the fissura inferior posterior the lobulus biventer reappears as a separate lobe, which in this specimen extends as far as the lateral border of the hemisphere.

The lobulus uvulatonsillaris has remained behind in its development, in comparison with the preceding lobes. It is only in a later period that the tonsillæ, independently of the uvula, begin to expand and to increase in size. The uvula shows now the first secondary groove, but often this groove is not visible from the outside, in consequence of the rolling inwards of the posterior border. By the same process the lobus noduloflocculаris disappears more and more from the inferior surface. Meantime this lobe partly atrophies, and it is only the nodulus and the two foremost lamellæ of the flocculus that become further differentiated. The wall of the posterior lamella of the flocculus atrophies and the fissura prenodularis, in as far as it limits the flocculus from behind, flattens and vanishes. The atrophy of the lamella and the disappearance of the fissure usually begin at the lateral margin of the hemisphere and proceed medially. By this process the posterior lamella of the flocculus is assimilated to the velum and the fissure that now separates the flocculus from the velum is no longer the lateral extremity of the fissura prenodularis, but the secondary groove, which initially divided the head of the flocculus into two lamellæ. At the same time, however, one or two small lamellæ are formed, emanating from the anterior surface of the flocculus. These lamellæ at the moment of their formation are concealed in the depth of the fissura preuvularis, but later one of these lamellæ may reach the surface.

The lobus nodiolovelaris also atrophies for the greater part, with the exception of those portions which form the nodiolus and the chorioid plexus. The atrophied parts of the lobe are also incorporated in the medullary velum.

In fig. 19 I reproduce the lateral aspect of the same cerebellum from the right side, because it exhibits many peculiarities. It shows the connexion between the uvulatonsilla and the lateral field belonging to this lobe. The lateral field itself is well marked and fairly large. In front this field is limited by a relatively deep groove, the lateral extremity of the fissura inferior anterior. In front of the fissura inferior anterior another groove is visible, which becomes flattened, and seems to end in the neighbourhood of the lateral margin of the hemisphere. This groove is the lateral extremity of the fissura inferior posterior, which borders in front the lobulus biventer. The small strip of substance between this latter groove and the fissura inferior anterior belongs, therefore, to the lobulus biventer, with which it is still in continuity. This fact proves that by the reappearance of the groove that borders in front the lobulus biventer, the original state is in reality restored. In most cases, however, this lateral part of the fissura inferior posterior does not reappear, and the groove ends at some distance from the lateral border of the hemisphere.

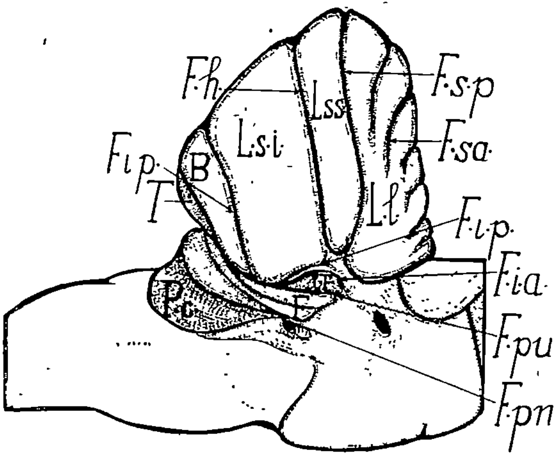

FIG. 19.—Lateral surface of a cerebellum of the end of the fifth month. Same cerebellum as reproduced in fig. 18. *B.*, lobulus biventer; *F.*, flocculus; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant., *F.i.p.*, fissura inferior post; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *F s.a.*, fissura superior ant.; *F s.p.*, fissura superior post.; *l.F.*, lateral field; *L.l.*, lobulus lunatus; *L.s.i.*, lobulus semilunaris inferior; *L.s.s.*, lobulus semilunaris superior; *P.c.*, plexus chorioideus; *T.*, tonsilla. Enlargement × 5.

In this specimen the fossa transversa makes its appearance as a little depression bordered anteriorly by the lobuli lunati and the lobulus semilunaris superior. The appearance of the fossa transversa indicates the beginning of the third phase in the development of the human cerebellum. It coincides approximately with the end of the fifth or the beginning of the sixth month. The chief characteristic of this third phase resides in the enormous expansion of the hemispheres. The enlargement of the surface, however, is not uniform throughout, but some parts increase, while others decrease or disappear. By this process of local differentiation the cerebellum approaches the adult form.

The expansion of the surface begins near the lateral border of the hemisphere, and is accompanied by a temporary flattening and disappearance of the grooves. There seems to exist a certain antagonism between furrowing and expansion, for, as soon as the expansion becomes less intense, the grooves reappear. The reconstruction of the furrows occurs, partly autonomously, partly by the outgrowth of the still existing branch of the groove. Most grooves, however, are not completely reconstructed, so that in the adult stage they no longer reach the lateral edge of the hemisphere. In such cases one gets the impression that the hemisphere winds like a gyrus round the end of the sulcus. This fact has probably led Bolk to the conception of a "lobulus ansiformis"; but it is evident that this conception has no fundamental importance, and can only lead to confusion.

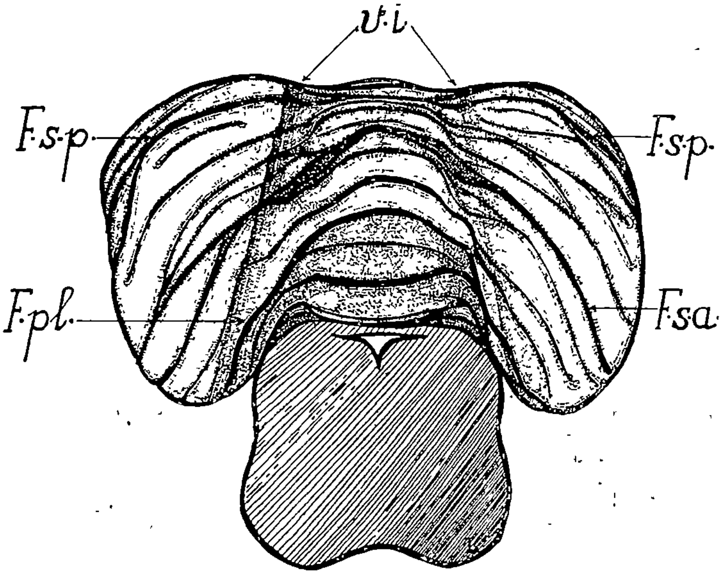

FIG. 20.—Superior surface of a cerebellum of the beginning or of the middle of the sixth month. *F.pl.*, fissura prelunata : *F.s.a.*, fissura superior ant. ; *F.s.p.*, fissura superior post. ; *v.i.*, vascular impression. Enlargement × 4.

The development of the superior surface of the cerebellum during the last phase is a mere continuation of the processes already mentioned. The vermis becomes more arched, but remains behind in its expansion in comparison with the hemispheres. The hemispheres become, therefore, the predominant parts of the cerebellum. There is no longer a distinct limit between the vermis and the hemispheres. In fig. 20 I reproduce the superior surface of a cerebellum of the beginning, or, perhaps, middle of the sixth month, to illustrate these relations. On both sides of the vermis a longitudinal impression is seen produced by the blood-vessels; but it is obvious that this impression cannot be taken as a limit between vermis and hemispheres.

The lingula at this stage of development has attained its definitive form, the alæ being separated from the middle division by a faint longitudinal groove. This groove is the last remainder of the sulcus paramedianus (fig. 21). The whole formation lies concealed in the depth of the fissura precentralis, covered by the lobulus centralis.

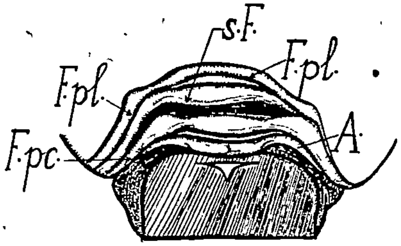

FIG. 21.—Anterior border of a cerebellum of the sixth month. Same cerebellum as reproduced in fig. 20. *A.*, ala lingulæ; *F.pc.*, fissura precentralis; *F.pl.*, fissura prelunata; *s.F.*, deep secondary furrow, dividing the lobulus centralis into two sublobules. Enlargement × 5.

The lobulus centralis is divided by a deep secondary groove into two sublobules. The foremost of the these sublobules has partly disappeared from the surface by the rolling inwards of the anterior border of the cerebellum (fig. 20). The hindmost sublobule, which is the larger one, is still visible, being only partly covered by the lobulus lunatus. Each of the two sublobules is again split up by a secondary groove, so that the whole lobulus centralis is composed of four sublobules. The fissura prelunata, which borders the lobulus centralis from behind, lies in this specimen still entirely in the superior surface, though, on the left, in consequence of the proceeding inward rolling of the anterior border, the furrow begins to disappear from the surface. In other specimina of approximately the same age the rolling inwards of the anterior border has further advanced, so that the lateral division of the fissura prelunata is no more visible. In this respect they more closely resemble the adult form.

A specimen of this kind is reproduced in fig. 22, as seen from the side. The cerebellum belongs to an embryo of the beginning of the sixth month. In this case the lobulus lunatus forms already a niche, in which the lobulus centralis is imbedded. In fig. 23 I reproduce a slightly older stage, in which the development of the lobulus lunatus has further advanced, and in which the covering of the lobulus centralis is more complete. The formation of the niche is the joint result of the rolling inwards of the anterior border and of the surface expansion of the lobulus lunatus.

The fissura superior anterior, which divides the lobulus lunatus into an anterior and a posterior division, is no longer the leading groove of the superior surface. For the formation of new lamellæ in the depth of the groove is no longer so active, and those that are formed do not reach the surface. In the lobulus lunatus posterior small lamellæ are formed, which unite the existing ones. The grooves, by which these small cross-lamellæ are bordered, form the "sulci pectinati obliqui" of Ziehen [23].

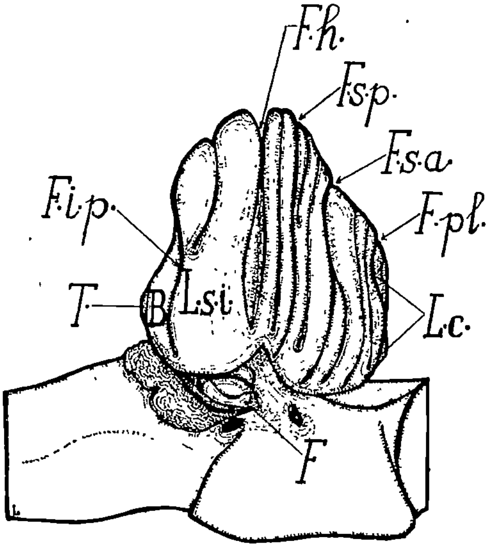

Fig. 22.—Lateral surface of a cerebellum of the beginning of the sixth month. *B*, lobulus biventer; *F*, flocculus; *F.h*, fissura horizontalis; *F.i.p.*, fissura inferior post.; *F.pl.*, fissura prelunata; *F.s.a.*, fissura superior ant.; *F.s.p*, fissura superior post.; *L.c.*, lobulus centralis; *L.s.i.*, lobulus similunaris inferior; *T.*, tonsilla. Enlargement × 4.

At this stage the fissura superior posterior, which limits the lobulus lunatus from behind, lies entirely in the superior surface. Laterally, where the groove approaches the lateral border of the hemsiphere, it is widened out (fig. 23). At the bottom of this little excavation, a small lamella is formed. This lamella, which first appears in the beginning of the sixth month, is not a constant formation, although I have met with it in the majority of the embryos I have examined (absent in the specimen reproduced in fig. 22). This little lamella develops into a small lobule, situated between the lobulus lunatus and the lobulus semilunaris, near the lateral border of the hemisphere and often protrudes into the fossa transversa.

From the middle of the sixth month onwards the lobulus semilunaris superior belongs almost entirely to the superior surface. Consequently the fissura horizontalis becomes the limiting groove between the superior and the inferior surface. The differentiation of the lobulus semilunaris superior begins at the end of the fifth month, with the formation of a large secondary groove, originating near the lateral border of the lobule.

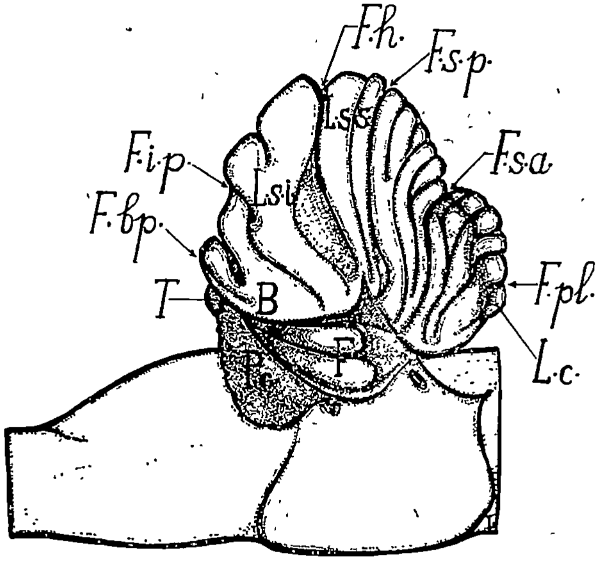

Fig. 23.—Lateral surface of a cerebellum of the beginning or of the middle of the sixth month. Same cerebellum as reproduced in figs. 20 and 21. *B.*, lobulus biventer; *F.*, flocculus; *F.bp.*, fissura bipartiens; *F.h.*, fissura horizontalis; *F.i.p.*, fissura inferior post.; *F.pl.*, fissura prelunata; *F.s.a.*, fissura superior ant.; *F.s.p.*, fissura superior post.; *L.c.*, lobulus centralis; *L.s.i.*, lobulus semilunaris inferior; *L.s.s.*, lobulus semilunaris superior; *P.c.*, plexus chorioideus; *T.*, tonsilla. Enlargement × 4.

In the course of the sixth month this groove extends medially but remains strictly confined to the hemisphere. In the adult this secondary furrow can easily be recognized, because it divides the lobulus semilunaris superior into an anterior and a posterior division (figs. 22 and 23).

The lobulus semilunaris inferior also increases in size, especially along its lateral border. At the end of the fifth month, the first secondary groove appears, soon followed by two other grooves on either side of the first one, so that at the beginning of the sixth month the lobule is subdivided into four parts by three secondary grooves (fig. 24). The grooves take their origin in the median margin of the lobule and extend laterally. Shortly after, new secondary grooves arise in a somewhat irregular way, whereby the four sublobules are further split up (figs. 24 and 25, on the left).

The tuber which forms the union between the two lobuli semilunares inferiores lags somewhat behind in its expansion in comparison with the lateral lobules, and thereby gradually loses its connexion with the hindmost sublobules of the lobulus semilunaris. These hindmost sublobules which have lost their connexion with the tuber are often described as forming part of a separate lobe, the " lobulus gracilis."

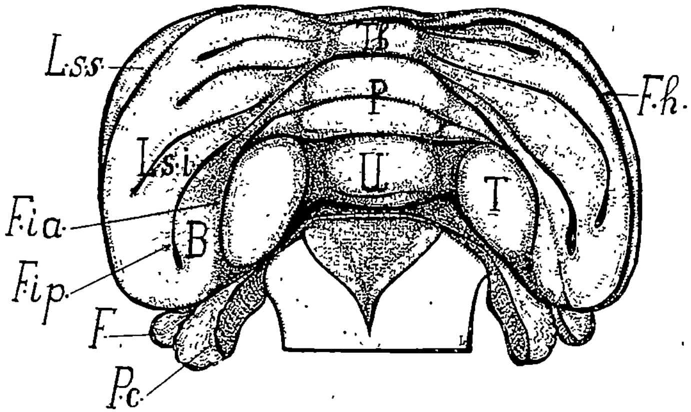

Fig. 24.—Inferior surface of a cerebellum of the beginning of the sixth month. Same cerebellum as reproduced in fig. 22. *B.*, lobulus biventer; *F.*, flocculus; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant.; *F.i.p.*, fissura inferior post.; *L.s.i.*, lobulus similunaris inferior; *L.s.s.*, lobulus similunaris superior; *P.*, pyramis; *P.c.*, plexus chorioideus; *T.*, tonsilla; *Tb.*, tuber, *U.*, uvula. Enlargement × 4.

The mode of reconstruction and the final course of the fissura inferior posterior may show many variations. In the more simple cases, the lateral division of the groove forms the direct continuation of the medial divisions (fig. 24 on the left and fig. 25 on both sides). In other cases, the groove approaches the fissura inferior anterior in the neighbourhood of the top of the tonsilla, unites with the latter for a short distance and then reappears as a separate groove (fig. 24, on the right).

In the first case we find a lobulus biventer in direct connexion with the pyramis; in the second, the connexion is not manifest, and, if existing at all, the uniting bridge between pyramis and lobulus biventer lies concealed in the depth of the fissura inferior anterior.

The pyramis itself is divided by a deep secondary groove into two sublobules (fig. 24). This secondary groove also extends laterally into the lobulus biventer, subdividing this lobule into an anterior and a posterior division. On its way laterally, the groove often touches the tonsilla, joining over a short distance the fissura inferior anterior, and then reappears as a separate groove (fig. 25). The anterior division of the lobulus biventer, which is by far the smaller one, is often described as forming part of the lobulus gracilis. The conception, however, of a lobulus gracilis, composed of elements belonging to two different cerebellar lobes, seems to me erroneous. I should rather be inclined to propose the denomination "lobulus gracilis" for the anterior divisions of the lobulus biventer, and "lobulus biventer sensu strictiori" or briefly, "lobulus biventer" for the posterior divisions of the lobe. In the adult form, however, it is often difficult, or even impossible, to recognise the fissura inferior posterior, and in those cases the true limit between the lobulus gracilis and the lobulus semilunaris inferior cannot be assigned. The posterior division of the lobulus biventer, or the lobulus biventer s.s., is split up by a secondary groove, emanating from the lateral border of the lobule. This secondary groove, which may always be recognized in the adult stage, is described by Ziehen as the "sulcus bipartiens" (fig. 25, on the right).

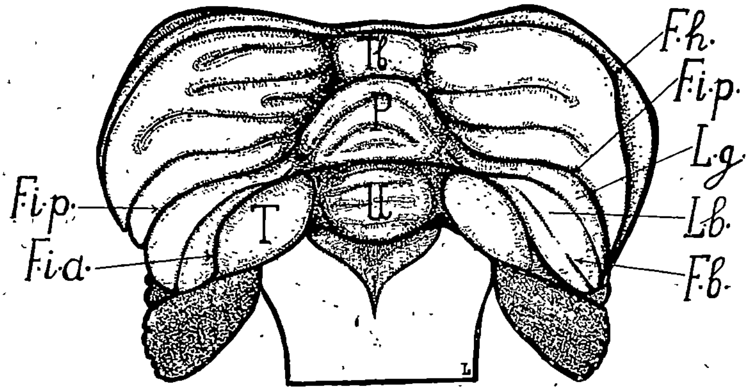

FIG. 25.—Inferior surface of a cerebellum of the beginning or of the middle of the sixth month. Same cerebellum as reproduced in figs. 20, 21, and 23. *F.b.*, fissura bipartiens; *F.h.*, fissura horizontalis; *F.i.a.*, fissura inferior ant.; *F.i.p.*, fissura inferior post.; *L.b.*, lobulus biventer, *s.s.*; *L.g.*, lobulus gracilis; *P.*, pyramis; *T.*, tonsilla; *Tb.*, tuber; *U.*, uvula. Enlargement × 4.

The fissura inferior anterior, which separates the lobus pyramido-biventricus from the lobus uvulatonsillaris, flattens in the neighbourhood of the lateral pole of the tonsilla and vanishes. The disappearance of the groove is caused by the atrophy of the more lateral part of the lobus uvulatonsillaris. At first this part of the lobe narrows and forms a small bridge joining the tonsilla to the little lateral field. Gradually the small bridge and the little lateral field flatten and disappear. At the same time the tonsilla, and especially its lateral pole, becomes more prominent and sharply marked off.

The position of the tonsilla is also altered. The longer axis of the tonsilla, which at first runs transversely, approaches more and more an antero-posterior direction. From within the sulcus paramedianus, the valecula has originated, and into this the tonsilla is pressed down by the expanding lobuli semilunares and biventer. The tonsilla, in this stage of development, shows no trace of secondary grooves, and it is only two or three weeks later that the first secondary groove appears, by which the tonsilla is divided into two sublobules (fig. 28, on the left).

The uvula is subdivided by a secondary groove into two lobules (fig. 24). This groove is situated near the posterior border of the uvula and is soon followed by other secondary grooves in a somewhat irregular way (fig. 25).

The fissura preuvularis, which forms the limit between the lobi uvulatonsillaris and noduloflocculаris, approaches more and more the posterior margin of the inferior surface. In consequence of the atrophy of the greater part of the lobulus flocculаris, the fissura preuvularis further flattens and disappears, so that this groove runs out in the neighbourhood of the lateral pole of the tonsilla. The extreme lateral part of the groove persists, and forms the anterior limit of the flocculus.

The lobulus noduloflocculаris can only be exposed to view by rolling outwards the posterior border of the cerebellum. In fig. 26 I reproduce such a preparation pertaining to an embryo of the beginning or of the middle of the sixth month. The nodulus is still connected with the flocculi by means of elongated triangular stalks. Vestiges of these stalks may persist in the adult state, forming the white brachium noduli. The nodulus is divided by two secondary grooves into three sublobules These grooves remain limited to the nodulus and do not extend into the stalks. The flocculus consists in this stage of development of only two sublobules, which begin to show the first traces of a further subdivision by grooves emanating from the lateral margin. On the left of fig. 26, the accessory flocculus is exposed to view by turning the flocculus a little aside.

The lobus noduloflocculаris is bordered from behind by the fissura prenodularis. The hemispherical part of this groove flattens more and more in the course of the sixth or seventh month in consequence of the atrophy of the corresponding part of the lobe. The atrophied part of the lobe is assimilated to the posterior medullary velum, and it is therefore from that moment on that the nodulus and the flocculus are united by the velum.

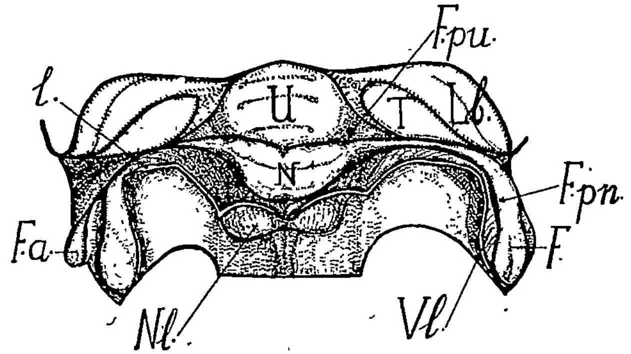

FIG. 26.—Posterior border of a cerebellum of the beginning or of the middle of the sixth month. Same cerebellum as reproduced in figs. 20, 21, 23, and 25. *F.*, flocculus; *F.a.*, flocculus accessorius; *F.pn.*, fissura prenodularis; *F.pu.*, fissura preuvularis; *l*, line along which the medullary velum is torn off; *L.b.*, lobulus biventer; *N.*, nodulus; *Nl.*, nodiolus; *T.*, tonsilla; *U.*, uvula; *Vl.*, velum medullare post. Enlargement × 4.

The hemispherical division of the last lobe, the lobulus nodiolovelaris, is entirely atrophied, and only the vermis portion persists. This part forms what I have termed the nodiolus. The nodiolus is separated from the nodulus by the middle divisions of the fissura prenodularis. The atrophied part of the lobus nodiolovelaris is incorporated in the velum and partly transformed into the chorioid plexus. In the preparation reproduced in fig. 26 the plexus and the more atrophied parts of the velum have been removed. The line along which these parts are torn off still runs across the nodiolus. This relation is only intelligible if we remember that the transition of the cerebellar plate into the velum did not lie at the posterior margin of the plate, but a little anteriorly. In a later stage of development and also in the adult state, the transition of the velum into the cerebellum lies more in front, at the bottom of the fissura prenodularis (fig. 29). In that case the whole nodiolus protrudes freely into the ventricular cavity covered from the outside by the velum.

The nodiolus is still undivided, but in a somewhat older stage this structure is also split up by secondary grooves. In the same way as the nodulus, the nodiolus is laterally prolonged into two stalks, the brachia nodioli. These brachia form part of the velum, of which they represent a less atrophied part. The brachia nodioli sometimes persist in the adult state as small white tracts, running parallel to the brachia noduli. In fig. 27, I represent the nodiolus and its brachia from behind and also the connexion between velum and brachia by means of a frenulum.

In the course of the sixth month the fossa transversa is completed by the formation of the hindmost lip (figs. 22 and 23). This lip is chiefly formed by the lateral margin of the lobuli semilunaris inferior and biventer. Initially, the fossa transversa is a broad triangular depression, but by the expansion of the hemispheres the two lips approach each other, whilst the fossa narrows and becomes deeper. The top of the groove lies a little anteriorly in respect of the lateral extremity of the fissura horizontalis, and in most cases this relation is the persisting one.

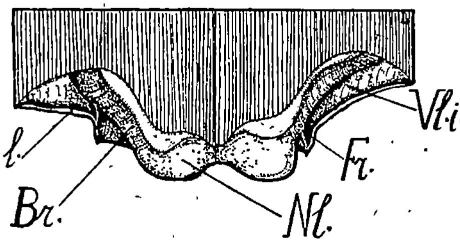

FIG. 27.—Posterior border of a cerebellum of the beginning or of the middle of the sixth month. Ventricular aspect. Same cerebellum as reproduced in figs. 20, 21, 23, 25, and 26. *Br.*, brachium nodioli: *Fr.*, frenulum; *l*, line along which the medullary velum is torn off. *Nl.*, nodiolus; *Vl.i.*, velum medullare post., ventricular surface. Enlargement × 4.

I end my description of the development of the external form with a cerebellum belonging to an embryo of the last half of the eighth month or perhaps slightly older.

The superior surface differs but little from the description already given. The number of lamellæ has increased by the formation of tertiary grooves, but the general feature of the surface has not changed. This is also the case with the inferior surface. This surface, by the increasing size of the hemispheres, approaches more and more the adult form. The folium has disappeared from the surface and in fig. 28 the connexion of the folium with the lobulus semilunaris lies concealed at the bottom of the fissura horizontalis.

The external surface of the tuber is subdivided into three lobules, which are connected with the three foremost sublobules of the lobulus semilunaris inferior. The posterior sublobules are for the greater part connected by means of white stalks with those lamellæ of the tuber which lie concealed in the depth of the fissura inferior posterior.

The pyramis is subdivided by a deep groove into two subdivisions. On the left, the anterior sublobule of the pyramis is in direct connexion with the anterior sublobule of the lobulus biventer (lobulus gracilis). On the right, this connexion is not manifest, and here it is the anterior part of the lobulus biventer s.s. which is connected with the foremost sublobule of the pyramis.

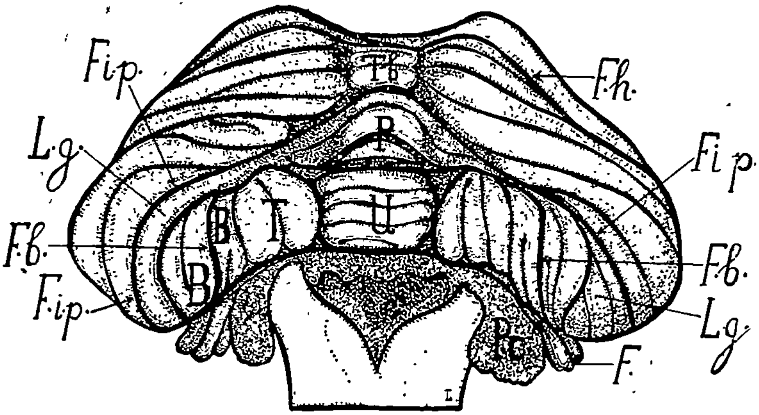

FIG. 28.—Inferior surface of a cerebellum of the last half of the eighth month. *B*, *B*, lobulus biventer, *s.s.*; *F.*, flocculus; *F.b.*, fissura bipartiens; *F.h.*, fissura horizontalis; *F.i.p.*, fissura inferior post.; *L.g.*, lobulus gracilis; *P.*, pyramis; *P.c.*, plexus chorioideus; *T.*, tonsilla; *Tb.*, tuber; *U.*, uvula. Enlargement × 3.

The uvula becomes gradually triangular, being compressed laterally by the tonsillæ. Meanwhile, the valecula broadens and deepens, forming the niche in which the tonsillæ are embedded. In this specimen the left tonsilla is divided into two sublobules by a secondary groove, which becomes later the fossa axialis of Ziehen [23].

In consequence of the increased rolling inwards of the posterior border, the lobulus nodulofloccularis can only be exposed to view by cutting away the tonsillæ and the brainstem. Fig. 29 is the reproduction of the preparation after removal of the more atrophied parts of the velum and the chorioid plexus. Because the velum has only partly followed the rolling inwards of the posterior border of the cerebellum, this structure is reversed along the posterior margin of the flocculus. The line, along which the velum and the plexus are torn off, disappears at the lateral border of the nodulus in the depth of the fissura prenodularis, so that the nodiolus as a whole is covered by the velum. The connected by means of white stalks with those lamellæ of the tuber which lie concealed in the depth of the fissura inferior posterior.

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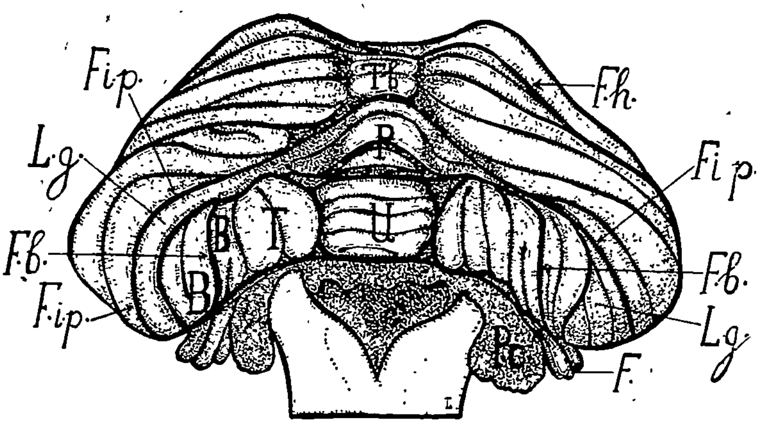

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Another merit of the scheme of Edinger is that it admits of a transverse subdivision of the cerebellum into lobes and that every lobe consists of an associated vermis and hemispherical division. The division by Edinger of the cerebellum into three principal lobes seems arbitrary, but nevertheless there exists some resemblance between the cerebellum at the end of the third month (figs. 7 and 8) and the scheme of Edinger.

The scheme of Bradley [3, 4] is not so simple as that of Edinger. He also recognizes the division of the cerebellum by purely transverse grooves, but in his scheme the vermis does not form a well-defined separate part. The division of the cerebellum into lobules resembles closely the division of the cerebellum of the first half of the fourth month (figs. 10 and 12), but the combination of these lobules into the five lobi A, B, C, D and E does not seem to be well founded. Especially the creation of a lobus C, composed by the lobi declivolunatus, foliosemilunaris and tuberosemilunaris, as well as the conception of a lobus D built up by the lobi pyramidobiventricus and uvulatonsillaris, does not seem in harmony with the facts observed in the human cerebellum.

In the scheme of Smith [17, 18], the fact seems incorporated that for a short time the furrowing of the vermis and of the hemispheres occurs independently, especially in the central zone of the cerebellum. Another merit of this scheme is the creation of a large area ptereoidea and post-ptereoidea. In these features the scheme of Smith would probably agree with a stage of development intermediate between the stages represented in figs. 8 and 10. Smith disregards, however, the fact that even in the central zone of the cerebellum the fissures of the vermis and of the hemispheres finally meet, forming complete transverse fissures.[2] Consequently, the Smith scheme has the disadvantage of not recognizing that the whole cerebellum, and not only his lobus anterior, is built up by transverse lamellæ. On this account the scheme is not fully applicable to the case of the human cerebellum.

More complicated and still less applicable to human relations is the scheme of Bolk [2]. In many respects this scheme resembles that of Smith. His conception of a lobulus ansiformis, and especially of a formatio vermicularis, as morphological entities, is not to be reconciled with the primary division of the human cerebellum by complete transverse fissures into ten separate lobes. Hence it seems impossible to recommend the application of the nomenclature of Bolk to the human cerebellum.

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[1] Experiments of Bárány [1] and others prove, that the flocculus is in close connexion with the vestibular system.

[2] With the exception in some cases of the fissura horizontalis.

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PART III, VOL. 42.

WAR-NEURASTHENIA, ACUTE AND CHRONIC.

BY D. W. CARMALT JONES, M.D., F.R.C.P.

Physician to Westminster Hospital, sometime Medical Officer-in-charge Medical Division, No. 4 Stationary Hospital, British Expeditionary Force (Neurological Centre), and Consulting Physician, Egyptian Expeditionary Force.

AUTHOR'S NOTE.

THE material used in this paper was collected during 1917 and the paper itself was written at the end of that year, when there appeared to be an indefinite prospect of hostilities before us. I have thought it best to let it stand as written. In most writings dealing with this subject great emphasis is laid on the psychical side of it, sometimes I think to the neglect of the physical side. I have here attempted to deal with the latter in monographic form, and to describe war-neurasthenia as a a physical disorder, with symptoms affecting most of the chief systems. I was unable at the time of writing to obtain access either to current or standard medical literature, hence the absence of references. The tentative observations on the importance of the state of the ductless glands in the condition, which now appears to be generally accepted, would have been modified in any fresh consideration of the problem; at that time little was heard about them.

INTRODUCTION.

There are many terms in common use in medicine which convey popular ideas with sufficient clearness, but which are not scientifically exact. Such words are "rheumatism" and "influenza," meaning respectively, pains, referred to the body or limbs; and headache, malaise and the accessory symptoms which accompany a mild general toxæmia, without more localizing signs than catarrh. One of the latest additions to the list of popular medical terms is "shell-shock," which includes all nervous disease induced by military service without obvious organic lesion. Among such are to be found all the usual manifestations of functional nervous disease, and on this account I have preferred the term "war-neurasthenia" as the title for this paper. The following pages are the result of a clinical study of these disorders, carried out under the following conditions.

In January, 1917, a centre was opened for the treatment of the cases of "shell-shock" from the 1st and 2nd Armies in France at No. 4 Stationary Hospital, first under the command of Colonel Bate, C.M.G., A.M.S., and afterwards of Lieutenant-Colonel Inkson, V.C., D.S.O., R.A.M.C.; general supervision was kept by Lieutenant-Colonel Gordon Holmes, C.M.G., Consulting Neurologist to the B.E.F.

The wards, and afterwards the Medical Division, allotted to the patients were in my charge, and for several months Captain A. E. Evans, R.A.M.C., assisted me. Other officers who served in the department for considerable periods were Captain J. Allan, R.A.M.C., Lieutenant W. L. Stewart, R.A.M.C., and 1st Lieutenant W. B. Terhune, U.S.M.O.R.C.

The department was open for nine months, during which period 4,700 patients passed through it; their records form the material on which this account is based. In the early part of the year patients were not numerous, and the majority of them were examined by myself, others by Captain Evans, working on a scheme drawn up by me, and in the same tent. Under this arrangement the first 1,300 patients were all examined in my presence, and subsequently treated and discharged by me; this series of cases has been used for statistical purposes and general close examination, though the results are interpreted in the light of the larger experience which was gained later.

The general object for which this and other centres were established was the return to duty of all possible patients, and the broad rule commonly observed, subject to the exigencies of the Service, was to send back all patients who became fit for duty within a month, and any who at the end of that time appeared to be still unfit were transferred to a base hospital.

The following account is a plain clinical study of the subject made by a general physician, with sufficient experience in disease of the nervous system to be able to make accurate diagnosis between organic and functional conditions. To ensure uniformity all patients were examined on a definite plan, in a special tent set apart for the purpose in which not more than two medical officers worked. A history of each case was taken, in which notes were made on the following points:—

(1) Name, number, unit, civil calling, age, total service, active service.

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(2) *Personal "nerve,"* as commonly estimated, capacity to work on heights, manage horses, and the like; games and sports followed; history of "nervous breakdowns." "Nerve" is a slang word in this sense, but it expresses the meaning required.

(3) *Previous strain,* period and character of active service; previous wounds or shock, and their effects.

(4) *The shock,* if any; history of being blown up or buried, or of gradually oncoming failure.

(5) *Symptoms:* Inquiry was made as to pain, and as to obtrusive subjective symptoms; as to appetite, digestion, bowels; micturition; respiration; sleep.

(6) *Physical signs:* The patient was stripped completely naked and notes made of his general development, nutrition and strength. A routine examination was made of his thorax and abdomen; he was put through movements to test the integrity of the motor and co-ordinating systems, and the chief reflexes were examined. The sensory system was as a rule ignored; no search for anæsthetic or hyperæsthetic areas was made because there is no reason to suppose that an anæsthesia of which a patient is unaware will affect his efficiency as a soldier, whereas one to which his attention is drawn may easily become a source of morbid interest.

Since the symptoms complained of in these cases are chiefly nervous a scheme has been drawn up for their classification on a nervous basis. The central nervous system is considered as separated into somatic and splanchnic divisions. The somatic division is separated into its usual components of sensory and motor systems, due note being made of the parts of each system on which the function of co-ordination depends. Every part of these systems has its proper physiological function, and when this function is disturbed symptoms arise. The functions may be disturbed in two ways, either by way of excess or by way of defect; thus on the sensory side pain is considered as sensation in excess, anæsthesia as sensation in defect; on the motor side contraction in excess is spasm, either tonic or clonic; contraction in defect is paresis; on these lines the list of symptoms has been constructed. A similar but less elaborate scheme for the splanchnic division has been employed in which note is taken of subjective and objective symptoms in the circulatory, respiratory, alimentary, and excretory systems.

The patients had all passed through a field ambulance and a casualty clearing station before admission; consequently all cases of shock were seen at least one, generally two, and often more days after the onset of symptoms, so that no experience was gained of the immediate conditions produced by shock; but the cases were as a rule of recent onset.

In view of the practical necessity for evacuation at the end of a month there was a similar lack of experience with regard to the late results in severe cases. Under a General Routine Order, all these patients were admitted marked "N.Y.D., N." (not yet diagnosed, ? nervous), and such cases are divisible into two general categories; the first and most serious is one of gradually acquired nervous breakdown, not referable to any specific explosion or to any accident such as being blown up or buried; it is obvious that any complete recovery from this condition, which may have taken two years' exposure to develop, is not to be expected in the course of a few weeks; it is discussed in this paper under the name of Chronic War-Neurasthenia. The second category includes cases rapidly induced by some of the accidents of warfare just mentioned, and differs from the former only in degree and not in kind; being rapidly induced it is much more rapidly cured, and it often has superadded to it hysterical symptoms such as mutism and paralysis, which are easily treated, although great sources of distress as long as they persist. These are the cases which are called Shell-shock, a most ill-advised but now established term. Shell-shock may, of course, occur with neurasthenia, or may form its starting point, or may first draw attention to it. I prefer to regard it as a state of Acute War-Neurasthenia.

The distinction quoted above is of little clinical interest, but was required by the higher authorities for disciplinary reasons, and at this time shell-shock was considered as a wound, and the distinction is preserved in all records, but in this paper the neuroses of war are considered as far as possible as a whole. Taking the distinction for what it is worth, there were among 1,300 cases, 612 of acute, 334 of chronic or established neurasthenia and 354 which were complicated with some form of organic disease such as bronchitis, rheumatism, pyrexia, or other disorders, requiring transfer to other departments or hospitals. The number of cases of organic disease of the central nervous system was exceedingly small, and was quite neglibible as having any bearing on the question of "N.Y.D., N."

With this material an attempt is here made to describe the neurosis of war as a clinical condition under the established headings of Definition, Etiology, Pathology, Symptoms, Physical Signs, Diagnosis, Prognosis, and Treatment.

If the popular word "nerve" correctly expresses the capacity to resist emotional strain, then I think the word *neurasthenia*, "weakness of nerve" is an accurate one for the condition found when that capacity is exhausted. But neurasthenia has other associations in most people's minds, and is frequently used in a derogatory sense, and if I have any point to make it is that there is nothing derogatory in neurasthenia honestly acquired on service. I have therefore prefixed the word "war" as a qualification, since "polemo-neurasthenia" would merely be precious, and would add yet another title to a list already too long.

DEFINITION.

A state of fatigue of the central nervous system, without organic change, manifested by asthenia, loss of physical and emotional control and disturbance of visceral functions.

ETIOLOGY.

In general terms the cause is physical and emotional strain, and the condition is due to yielding thereto; and since yielding to any strain involves consideration of the character of the strain itself and the qualities of the thing strained, both have to be considered under exciting and predisposing causes.

Search for predisposing causes has been unprofitable; neither age nor occupation afford any guide.

Age.—The age-incidence in a thousand consecutive cases has been worked out as follows: the cases are divided into five yearly groups—18 to 22 (and under), 23 to 27, 28 to 32, 33 to 37, 38 to 42 (and over), with this result: first group, 381; second, 274; third, 184; fourth, 89; fifth, 72. This, of course, is of no value except when compared with the proportions of troops serving in these age-groups, and such figures are not available. At a guess, the two correspond fairly closely, though it may be doubted if 38 per cent., that is, more than one-third, of soldiers exposed to trench warfare are under 23 years of age. On the whole, it seems probable that the very young soldier is especially liable to nervous breakdown.

Occupation: This was classified in 500 cases with equally unprofitable results. The occupations are grouped as: *Indoor trades:* weavers, mill-hands, dyers, metal workers, &c. *Indoor callings:* clerks, draughtsmen, shopmen, servants, &c. *Outdoor trades:* bricklayers, painters, plasterers, &c. *Outdoor callings:* labourers, chauffeurs, carmen, police, &c., *Underground workers:* miners. And give the following results:—

Outdoor trades and callings, 231. Indoor trades and callings, 225. Miners, 44.

"Nerve," as estimated by the patient, has been tabulated in 300 cases, and very roughly grouped as "good" or "bad"; "good" being the men who had had no trouble with their nerves at home, who could manage horses or work on high ladders, and who took their amusements in such sports as boxing or football; "bad" are men who had only been able to follow the less exacting occupations in civil life, who played no rough games and had suffered from "nervous breakdown." Intermediate cases were put as near one group or the other as might be. Among these cases there was a small majority on the side of those with "good" nerve. There has been no opportunity of estimating how far the internal discipline of any given battalion modifies the incidence of neurasthenia among its members.

There is enormous difference in the resisting powers of individuals; some men come down in a few weeks, a few have lasted three years and a half, and all intermediate stages are to be found, but they appear to depend much more on a man's individual qualities than on his circumstances, that is, they are a matter of heredity rather than environment. It is, of course, what one would expect; if you start a dozen men level to run a mile race, they will finish in a string, according to their lasting powers; and so it is with their lasting powers for the strain of war. The type known to neurologists as "degenerate," which contains many epileptics in its ranks, with the physical characteristics of narrow palate and crowded teeth, simian hand and coarse skin, has been found frequently among these patients. I have come to regard a narrow palate as indicating a bad prognosis.

Exciting Causes.—These are the various physical and emotional stresses of war, and may be individually well borne but producing cumulative effect (chronic war-neurasthenia), or, if sufficiently sudden and violent, may produce immediate effect (acute war-neurasthenia); specimens of each are given from patients' histories.

Gradual onset (chronic type). The cases are arranged according to length of active service.

Case 1.—Sergeant H., aged 22; two years in France. Previous nerve good, played football for battalion, boxer; has done very well, done everything, lasted through Somme, wounded, promoted Sergeant, D.C.M. Suffering from general strain, no special explosion. For three months bad sleep, loss of concentration, worrying, losing flesh, irritable, avoids society, nothing to say, emotional, loss of self-confidence, formerly fond of risk.

Case 2.—Sapper L., aged 32; two years in France. Nervous in any danger, no games or sport. Twice in blown-up mine, much frightened but not injured. Since then nerve worse. Kept back at headquarters. No recent shock;

two weeks ago returned to line, under heavy bombardment, could not stand it.

Case 3.—Private M., aged 22, one year nine months in France. Nervous at night, otherwise nerve fair. Good in France, wound fifteen months ago, nerve unaffected, lasted well till recently, through the Somme, four times "over the top." Two weeks ago heavy shelling, shell dropped in next bay, alarmed, not knocked down or unconscious. Since then has lost control in heavy shelling, no true shock. Recently four days under fire, became shaky, running about trench, not knowing where to go

Case 4.—Lance-Corporal K., aged 21; one year six months in France. Nerve never good at home, but good in France for nine months. One year ago "shell shock," away four months. Served as pioneer through winter: all right till one month ago when battalion went into line, served one day, became excessively nervous, trembling in any shell fire, with præcordial pain.

Case 5.—Sergeant S., aged 28; one year five months in France. Nerve good, footballer, regular soldier. Out November, 1914, wounded Neuve Chapelle; rejoined July, 1915; shocks Somme, 1916; rejoined April, 1917; nerve good till Somme, since then deteriorated. No good now, cannot stand any shelling. Five days ago, some hours' bombardment, not very heavy, not laid out by any shell, taken to aid-post.

Case 6.—Private McG., aged 31; one year two months in France. Previous nerve good, boxer, swimmer; good in France at first, no wounds, well till five months ago when next bay was blown in, stunned, unable to carry on; one month at transport, returned to line, sent down again three times. Shaky in all excitement, at first only under bombardment, now on the least provocation.

Case 7.—Gunner P., aged 34; one year one month in France. Previous nerve good, footballer, runner, cyclist; nerve good in France, no wounds or shock; deteriorating since the Somme, mate killed in dug-out he had just left. Six days ago battery shelled out, thrown across trench, dazed but not unconscious, could not carry on.

Case 8.—Pioneer L., aged 20; one year in France. Nerve good at first; nine months ago blown out of bed, billet destroyed, mate killed. Nervous in Somme, some shock, but did not leave unit, no recollection of what happened for a fortnight, record of some unusual behaviour: permanent light duty since. Shocked again later, memory imperfect. No shock this time. Reported sick frequently with pains in head, weakness in legs, tingling limbs and inability to open fingers.

Case 9.—Private Le G., aged 18; ten months in France. Previous nerve never very good, but good in France; buried six months ago, away six weeks. Domestic worry, father, mother and brother all killed, nerve not good since. Sent out of the line two or three times. No recent shock, has several times fainted on the march.

Case 10.—Private K., aged 21; nine months in France. Nerve poor at home, better than he expected in France. Gradual deterioration, no wounds or shock.

Case 11.—Sergeant M., aged 26; six months in France. Gradual deterioration, nerve poor after shelling but carried on at first; later sent down by officer for a month, returned to line, tremulous under fire, twice sent down.

Case 12.—Gunner M , aged 23; three months in France. Nerve poor. No good on guns, upset by our own fire; no shock, reported sick with nerves and loss of sleep.

These cases illustrate well the different lasting power of different men, from fine soldiers like No. 1, to such "military misfits" as No. 12, and the varying period which they take to arrive at the same conditions.

Sudden onset (acute type).

Case 13.—Knocked out by heavy shell, unconscious probably an hour. Shaky, pains in head, emotional, laughing and crying.

Case 14.—Buried, not unconscious, lost self-control; emotional, shaky, unable to carry on.

Case 15.—In gun-pit, direct hit on gun; thrown about ten feet on to ammunition, stunned a few minutes, able to get out alone, shaky, not crying, very frightened.

Case 16.—Partly buried by trench-mortar shell, knocked out, could not carry on, trembling, not emotional.

Case 17—Asleep in dug-out, knocked over, not unconscious, could walk down, became unsteady, shaky, crying.

Case 18.—In dug-out which was wrecked, unconscious half an hour, could walk down with help, unable to carry on, shaky, head aching, not emotional.

Case 19.—Knocked out by trench-mortar shell, unconscious more than an hour; later, mute for three days, stammering two days.

Case 20.—Shell entered dug-out, unconscious an hour, shaky, walked down with help, lost speech, unable to carry on, emotional.

Case 21.—Caught up in wire, blown up, unconscious an hour, could not stand, giddy, dazed, emotional.

Case 22.—Knocked out, buried, stunned a short time, dazed, imperfect memory, shaky and crying.

Case 23.—Buried, stunned a few minutes, deaf, ringing in head, shaky, not emotional, could speak, unable to carry on, could walk down.

Case 24.—Knocked out, unconscious a short time, buried, could not walk, trembling and emotional.

The similarity of these histories is remarkable, and compared with those of the cases of the chronic type, shows that the only differences between the two are due to the rate of their onset, whether suddenly or gradually induced. Out of 1,200 cases 822 were of rapid and 378 of gradual onset, roughly 70 per cent. and 30 per cent., rather more than 2 to 1.

The exciting causes of war-neurasthenia then are *physical fatigue*, *physical violence*, such as being blown up and buried by shell explosions, and *emotional strain* such as continued alarm, the loss of comrades, other distressing sights and sounds, along with the continuous effort of self-control under impulses to seek safety.

PATHOLOGY.

No information was obtained as to the morbid anatomy of the condition. Three deaths occurred in the 4,700 cases of this series, two from cerebrospinal meningitis, and one from broncho-pneumonia. Postmortem examinations were made in each case, but the state of the brain and spinal cord and other organs threw no light on the pathology of war-neurasthenia.

In cases of sudden onset such as that described in Case 15, in which a man was said to have been thrown 10 ft. across a gun-pit on to a heap of ammunition, it is clear that any degree of physical injury may occur. I have seen cases of fractured base of the skull, and fracture-dislocation of the spine. I have heard of a case in which the corpus callosum was found to be torn across without external injury, and many minor lesions occur, such as hæmorrhage into the conjunctiva or the membrana tympani, and punctate lenticular opacities said to be due to physical violence. I have records of seven cases of epistaxis, and one of hæmoptysis. All such things, however, are in my opinion complications of the condition. Punctate cerebral hæmorrhages have been described by several eminent neuro-pathologists, but if these were the rule, one would, I think, more frequently find evidence of organic injury, such as lesions of cranial nerves or about the red nucleus, or changes in the reflexes of organic type. Judged by the old-fashioned standard of the reflexes the condition is essentially one of functional disease of the nervous system, by which I mean a condition in which all nerve cells and fibres are structurally intact. These cases, therefore, provide no pathological facts. I give later an hypothesis as to a possible physiological perversion which would explain some of the symptons.

SYMPTOMS.

A severe case, with sudden onset, without hysterical symptoms, seen a day or two after the event, presents an appearance much as follows:—

The general appearance of the patient is apathetic, while in quiet surroundings his face is rather anxious, but has not much expression; sometimes the eyes are widely opened in a stare. He starts violently at any loud noise, and may duck suddenly and excessively on passing under cover, as for instance through a tent door. On questioning he will volunteer very little; he is often very slow to understand; he hears the words but there is some delay before he takes in their meaning; he is generally quite frank in his answers, which are nearly always corroborated by statements from his unit, and prove to be rather under than over estimates of the fact. He is frequently emotional, and breaks down into tears under examination. His general aspect is one of fatigue; he is slouching in movement, stands with rounded shoulders, bowed head and slack knees. The strength he exerts is below what is to be expected from his development, all movements are made with reluctance. He complains as a rule of headache, and often of præcordial pain; he is dizzy on rising. The pulse-rate is often rapid. The appetite is poor, and constipation is frequent. Micturition is often precipitate. Tremors are common, often increased on intended movement; the deep reflexes are generally very brisk without increase in tone. The pupils are sometimes widely dilated. Sleep is generally delayed and broken The course is on the whole towards recovery, at any rate in first attacks, and proceeds at a speed which varies with the severity and prolongation of the strain, and the natural recuperative power of the patient. Recovery is not as a rule uniform, but is broken by a series of recurrences of symptoms, becoming as a rule progressively slighter and at greater intervals. The increasing smartness displayed by patients at sick parade is very striking, and there is in many cases a point at which men definitely turn the corner; for some days or weeks there is a reluctance to admit improvement, associated, as I believe, with a feeling that they could not face service conditions; but there comes a day when a man stands up perfectly straight, clicks his heels and salutes smartly, and when asked how he is replies, "I feel champion, sir."

Headache	736	57 per cent.
Disturbed sleep	515	40 ,,
Inco-ordination	374	29 ,,
Pain, other than headache	303	23 ,,
Asthenia	266	20 ,,
Alimentary symptoms	251	19 ,,
Cardio-vascular symptoms	237	18 ,,
Urinary symptoms	204	15 ,,
Psychical symptoms	196	15 ,,
Aural symptoms	191	14 ,,
Respiratory symptoms	104	8 ,,
Ocular symptoms	92	7 ,,
Mutism	85	6 ,,
Paræsthesia	78	6 ,,
Paresis	41	3 ,,
Anæsthesia	37	3 ,,

I have made a numerical estimate of the symptoms complained of in these 1,300 cases, which is given above; some of them are to be regarded as complications, but they are all grouped together in a single series. They are compiled from the histories taken on the admission of patients, thus avoiding symptoms due to suggestion from and mimicry of comrades. The subjective ones are only those volunteered by patients.

On the preceding page is the incidence of the symptoms in these cases in tabular form.

Having adopted the view that war-neurasthenia is primarily a functional disease of the central nervous system, I take the directly referable symptoms of the disorder to be disturbances of the functions of sensation, movement and co-ordination; but visceral disturbances require separate consideration. Properly, in my opinion, hysteria is not of the essence of the condition and should be regarded as a complication, but the two are so closely associated that separation is impracticable.

The symptoms are divided up on the following scheme:—

- CENTRAL NERVOUS SYSTEM
  - SOMATIC
    - SENSORY
      - Sensation in excess ..
        - Common sensation: Pain; Paræsthesia
        - Special sensation..: Scintillations; Tinnitus.
      - Sensation in defect
        - Common sensation: Analgesia; Anæsthesia
        - Special sensation..: Blindness; Deafness
      - Muscular sensation in defect
    - MOTOR
      - Defective harmony of opponents
        - (Inco-ordination) (with Muscular sensation in defect): Sensory inco-ordination; Motor inco-ordination
      - Contraction in excess .. .. ..: Clonic spasm; Tonic spasm
      - Contraction in defect. .. .. ..: Asthenia; Paresis
  - SPLANCHNIC
    - VISCERAL
      - Circulatory ..
        - Subjective ..: Giddiness; Palpitations
        - Objective .. Tachycardia
      - Respiratory ..
        - Subjective .. Dyspnœa
        - Objective .. Asthma
      - Alimentary ..
        - Subjective .. Anorexia, pain
        - Objective .. Diarrhœa, constipation
      - Excretory .. ..
        - Subjective .. Pain
        - Objective .. Frequency, infrequency

Also PSYCHICAL SYMPTOMS and disturbances of SLEEP.

It will be observed that the commonest symptoms are those of common sensation in excess, disturbance of sleep, and disturbance of co-ordination, that pure motor symptoms, with the exception of asthenia, are rare, that visceral disturbances and also psychical symptoms are common though not invariable, and that disturbance of the special senses is infrequent.

The chief of these may be considered rather more in detail. Notes were made only when the patients volunteered information about their condition, it being desirable to avoid suggestion. Had more inquiry been made, the numbers of all symptoms would doubtless have been larger, but I expect the proportions would have been maintained.

DISTURBANCES OF SENSATION.

Pain.—Headache, 736 cases.

Site.—Described as frontal in 65 cases, occipital in 55, vertical 17, unilateral 15, temporal 13, eye 8, referred to site of old wound 9.

Time.—Worst in early morning 16, at night 13.

Induced by change of position rising or stooping 17, by noise 16.

Character.—Shooting 17, throbbing 10, pressure 10, neuralgia 5, and occasionally described as "bursting," "top lifts up and down," "rattles," "splitting," "knocking," "in a vice."

I have not gathered the impression that this headache, so commonly complained of, is in fact usually very severe. It is often stated to be present in men who have no appearance of being in serious pain, and when pressed by such questions as, "But you are surely not in very severe pain now?" will admit that they are not, but say that they have recently been so. Like all purely subjective symptoms, it is of course liable to exaggeration and also simulation, and my own impression of it is that it is real, not as a rule severe, but always ill-borne. Occasionally one is convinced of its severity.

In treatment I have found drugs of very little value; the tar products, aspirin, phenacetin, and the like do little good. Physical applications are the best; I have had good results from hot-water bottles and fomentations for occipital pain, and ice-bags and evaporating lotions for frontal pain; blisters to painful spots have several times given relief, and there sometimes is improvement when pillows are packed so as to raise the head at night; instructions should always be given to change the position slowly.

Lumbar puncture was performed nineteen times for relief of pain with the following results. The puncture was always made in the sitting position, without an anæsthetic. The pressure was never measured mechanically but evidently varied considerably; in some cases a well-maintained flow was obtained, while in others there were only a few drops. Several times, though the needle was apparently in the theca, no fluid was obtained.

Case 1, 15 c.c., no relief.
Case 2, 15 c.c., much improvement.
Case 3, 15 c.c., relief for one day, recurred.
Case 4, 15 c.c., much relief.
Case 5, 15 c.c., great and maintained improvement.
Case 6, 8 c.c., great relief, changed character.
Case 7, 7 c.c., great relief, changed character, recurred.
Case 8, 4 c.c., temporary improvement, recurred.
Case 9, 2 c.c., relief.
Case 10, 1 c.c., no improvement.
Case 11, a few drops, no improvement.
Case 12, a few drops, slight improvement.
Case 13, blank, relief, recurred.
Case 14, blank, relief, recurred.
Case 15, blank, relief, recurred.
Case 16, blank, some blood, great and maintained improvement.

In three cases the needle did not appear to have reached the canal, but in two of these the patients described themselves as better.

The precise value of lumbar puncture is not very clear from this; but as a rule where headache is persistent and really appears severe, plenty of fluid can be withdrawn and this is often followed by striking relief.

Pain, other than headache.—Recorded in 303 cases; where particulars are given they are as follows: They are chiefly referred to the back, shoulders, loins and neck (61 cases); they are generally described as "aching" without more detail, sometimes "like a red-hot needle sticking in my back."

Pain in the chest, generally definitely præcordial, comes next (47 cases); this is variously described as a "grip on my heart," "catching," "shooting," or added to a sense of heart-stopping. This is referred to again under the Circulatory System.

Pain in the legs is noted thirteen times, in the limbs four times, and "all over" twice; definite cases of trench fever (recurrent pyrexia and shin pains) are not included in this list, but these cases probably belong properly to that category.

Pain in the abdomen is complained of six times, and pain in an old wound, or the site of an old pleurisy, occurs five times (*cf.* headache, referred to the site of an old wound).

I have found here again that physical remedies are most effective, and that blisters to the chest are the most satisfactory treatment for præcordial pain.

Hyperæsthesia though occasionally met with was never investigated.

Paræsthesia.—Details of paræsthesia were not sought after.

Those noted are chiefly numbness and cramps in the extremities. A curious abdominal sensation is often complained of, and is nearly always described in the same way—"My stomach turns over and over." General malaise is not infrequent, and globus hystericus was occasionally noted.

Anæsthesia and analgesia were not systematically looked for, but under this heading I have included cases of stupor and of hysterical fits. There are notes on thirty-seven cases of anæsthesia. Anæsthesia in these cases is an hysterical manifestation, and is a condition in which stimuli of ordinary intensity, though received by the afferent nerves, are not realized, or at any rate not interpreted, by the centre of consciousness. This applies equally to common sensation and to the special senses. The depth of anæsthesia varies, but if sufficiently powerful stimulus can be applied it will be felt, and once anything is felt stimuli of ordinary intensity can soon be felt likewise. This is the general rule: cases occur in which no stimulus which can be applied without risk of injury can be felt.

The most pronounced cases met with are those of stupor, of which I have notes on nine. The majority were roused without difficulty; one man remained stuporose for three or four days; he could be induced to take food, but otherwise lay in bed taking no apparent interest in his surroundings. The commonest condition is that of a man who will make no spontaneous action, and has to be carried on a stretcher; he generally has his eyes open, but does not understand questions; he may ask for a smoke or a drink, or call out for a comrade. In milder cases he can be induced to get up and move about in an automatic manner; in this state he will walk out of a tent without his clothes, unless checked. At times a patient cannot be roused at a single session, but after a few hours in bed, or perhaps the following morning, wakes up quite rational. The following cases illustrate degrees of the conditions:—

Case 25.—Rifleman R., carried to inspection tent on stretcher. Quite unaware of surroundings; could copy movements. Induced to sit up. A dinner bell was rung loudly behind him, and after a few seconds he began to flinch and hear. Soon after this he became aware of where he was, and in a few minutes could read and identify objects. He then gave his name in a whisper, rapidly recovered phonation, and became quite rational. He stated that his first consciousness came with hearing the bell; his memory gradually returned.

Case 26.—Private G. Could neither hear nor read, but was able to eat and to dress himself. Faradization with wire brush, strong current not felt at all for several minutes, but afterwards it became painful and he cried a little, and said, "It hurts." Flinched at sound of a loud bell. Copied movements. Next day consciousness returned spontaneously, he could hear but not speak; speech was restored in a few minutes, but with a stammer, which improved but was never quite lost while in hospital. His memory was quite clear up to the time of his shock.

Case 27.—Lance-Corporal H., stated to have been alternately laughing and violent at the regimental aid-post. On admission he could understand signs a little, but could neither hear nor read. Roused a little by faradization, and induced to stand.

Next day there was some improvement: he could walk, but would walk out of the tent half-dressed; he flinched at the bell. A few hours later consciousness returned; he could hear one's voice at about four inches, but could not speak; speech was restored in about an hour, but was very slow and hesitating. He was quite intelligent, but had persistent difficulty in finding the right word, either spoken or written; this was probably partly because, though an Englishman, he had lived chiefly in France, and did not know English very well.

Case 28.—Rifleman N., admitted unconscious, gesticulating wildly and talking gibberish. Under strong faradization recovered consciousness gradually, was induced to stand, answered his name, gave name and unit, and wrote his address, reversing several letters.

There were two other cases of general anæsthesia without unconsciousness, one marked case of hemianæsthesia and hemianalgesia, one of anæsthesia of the legs associated with paresis, which recovered under faradization, but relapsed.

There were three cases of violent hysterical fits, aborted in the usual way by cutaneous stimulation.

Loss of sense of deep pressure on muscles is considered later under "inco-ordination."

Disturbances of special senses, both excess and defect, are considered together, along with the accessory symptoms such as squint, which are generally referred to specialists.

Ocular symptoms : Ninety-two cases.

Change in visual sensation.—No cases of functional blindness occurred, but vision was "blurred" in twenty-eight cases, sometimes especially on rising, and probably associated with the dizziness on rising previously noted.

Inability to read because "print all runs together" is a common complaint, and failure to accommodate for near vision, the effort failing below 12 or even 18 inches, was many times observed by Captain Evans. I have noted the fact twelve times. Associated with this are diplopia, squint and imperfect outward movement of the eyes noted ten times, in one case a definite convergent squint with spasm of accommodation was relieved by atropine. Another case of headache referred to the same cause was relieved in the same way. There are thus cases both of spasm and of failure of accommodation. Many subjective phenomena are complained of, scintillations or specks thirteen times, chromatic abnormalities eight times. The following are specimens: "Sees objects moving at night, different colours," "colours floating before the eyes," "things go black," "everything went blue," "everything goes white," and also "sees rings which get larger and smaller," "objects recede on trying to focus," "everything seems bigger." There is occasional photophobia.

In nine cases it was noted that the pupils were very wide, but reacted to strong light. In thirteen cases the eyes were very widely opened, showing the whole cornea in a stare, and sometimes showing von Graefe's sign of delayed descent of the upper lid on looking down. I have never seen any true exophthalmos in these cases, the eyelids merely being held very widely open. Lenticular opacities were observed three times, and once attention was drawn to the condition of an old amblyopic eye, which had previously given no trouble; this is probably comparable to the reference of pain to the site of a previous wound.

A point several times observed is that patients obstinately refuse to look at the examining medical officer. Hæmorrhages into the conjunctiva were occasionally seen.

Aural symptoms : 191 cases.

The symptoms complained of are deafness, deaf-mutism, and tinnitus.

Deafness may be functional, organic, or functional on an organic basis. In aural disease, perhaps more than any other, is a previous or latent injury likely to be aroused.

There is pure functional deafness, with or without mutism; it is an anæsthesia, and neither bone-conducted nor air-conducted vibrations are appreciated. In many instances, as described under Anæsthesia, a sound, if sufficiently loud, can be heard, such as a loud bell. Words shouted through a stethoscope can often be heard, and once heard, ordinary hearing may be quickly restored. In the course of a single session a patient, who can hear nothing at all at first, may be able to hear words spoken at the ordinary conversational pitch, say in half an hour's time. Guard must be kept against the psychical condition in which words can be heard and repeated but convey no meaning. Some cases are very resistant, many will flinch when words are shouted down the stethoscope, who are not conscious of hearing any sound.

Deafness may also be organic, all degrees of injury to the tympanum and ossicles being met with. Acute otorrhœa is, of course, very common in youth as a sequel of measles, scarlet fever and respiratory catarrh, often becoming chronic or latent. Such cases are frequently much aggravated both by exposure to shell fire, and by the imperfect facilities for cleanliness available on service.

Tinnitus is still commoner than deafness, and is described variously as "ringing," "thumping," "bell ringing," "hissing," "throbbing," "like motor lorries," "drumming," and so on.

The prognosis for hearing is good in functional cases. I have the following notes:—

Case 29.—Deafness, recovered.

Case 30.—Deaf-mute, cured at once.

Case 31.—Deaf-mute, induced to speak, hearing recovered in a week.

Case 32.—Hearing lost, gradually recovered.

Case 33.—First day, could not hear own voice; second day, could hear noises but not distinguish sounds; third day, could hear fairly. This patient relapsed.

Case 34.—Deaf-mute, speech restored, and with it some hearing, but this was completely lost later, although he flinched on shouting down the stethoscope. There was considerable organic damage to the drum.

The most effectual treatment, in my experience, is daily re-education with bells, stethoscope and so on.

Disturbance of other special senses has rarely been met with; there was one case of parosmia, the man being aware of a persistent smell of poison gas, and one case of the loss of the functions of taste and smell, in a grocer with a cultivated taste for butter.

Disturbance of co-ordination.—The faculty of muscular movement is useless for the purpose of human activity without the faculty of precision of movement, which is attained by the co-ordination of muscular contractions. Co-ordination has two aspects—sensory and motor. For any movement of precision it is necessary to be aware of the position in space of the limbs involved, which varies as different joints are moved, and this depends on the integrity of the sensory apparatus, and if that is out of order precision cannot be attained. Motor co-ordination is the harmonious action of opposing groups of muscles which control the degree of movement of individual joints. Such a movement of precision as that of bringing the hand from the side to the mouth requires flexion of the elbow, by contraction of the biceps and brachialis anticus, but flexion must be stopped at a given point and this depends on the action of the antagonist of these muscles, namely, the triceps, which acts as a brake and checks the movement of flexion at exactly the right moment.

Both sensory and motor co-ordination are disturbed in organic diseases which involve special parts of the central nervous system concerned in these functions. Sensory co-ordination is disturbed in tabes dorsalis, the tabetic gait being due to loss of sense of position of the limbs, so that the feet are thrown unduly high in the air, because the sensory impulse which should indicate their position is absent. Motor inco-ordination is present in disseminated sclerosis when the red nucleus or the tracts communicating with it are disordered. When this occurs, muscles and their opponents do not act in harmony, but alternately, producing tremors, and precision of movement is thus lost.

Both sensory and motor co-ordination may be functionally disturbed after shock.

Sensory inco-ordination.—Tabes dorsalis is the typical organic condition which produces sensory inco-ordination, and the general assumption is that in tabes those parts of the cord are first affected along which impulses from muscles and joints are conveyed. Consequently one finds the tabetic gait, and the common phenomenon of missing the nose with the finger with the eyes closed, and increase of unsteadiness in standing on closing the eyes. In addition to this there is astereognosis, inability to describe the position of limb without seeing it; loss of muscle pressure sense, when the calf or other muscular mass can be squeezed forcibly without pain; and also the loss of tone and abolition of the deep reflexes. Many of the phenomena in this list, namely, inco-ordinate gait, Romberg's sign, astereognosis and loss of muscle pressure sense may occur after shock, though not as a rule all together. Confusion with tabes may easily arise: the following case occurred early in my experience:—

Case 34.—An officer, aged 41, three months in Ypres Salient, nerve unaffected. Eight days before admission was knocked out by a shell, unconscious a short time, then carried on for twenty-four hours. Suffered from severe headache and sense of numbness over occiput, difficulty in walking, great weakness and loss of control of legs, walked as if drunk. Passed no urine for two days, bowels not open for four days.

On examination: Pupils sluggish but reacted to light. Transient squint. Great inco-ordination of hands of sensory type, missed his nose by several inches with the eyes shut, inco-ordination of legs, unsteadiness in standing much increased by closing eyes, gait inco-ordinate; sphincters, delay. Deep reflexes, knee-jerks increased, ankle-jerk present.

The combination of sensory inco-ordination of arms and legs, transient squint, and delayed relaxation of sphincters, occurring in a man of 41 after prolonged exposure to severe campaigning is strongly suggestive of tabes, which was my diagnosis, but all symptoms cleared up after two or three days' rest.

I have found sensory inco-ordination, as shown by the finger-nose test, in fifteen cases, loss of position sense in eleven cases and loss of muscle pressure sense, in the absence of any particular anæsthesia of the skin, in six cases. A reeling gait, in which, as a rule, the legs are crossed, is sometimes found, an hysterical Romberg's sign may be found, and such ordinary functional symptoms as astasia-abasia and retrogression are not uncommon.

Motor inco-ordination.—This is manifested by tremors, by which I mean the alternate rapid action of antagonistic muscle groups about any given joint. The most frequently observed being alternate slight pronation and supination of the wrist producing the shaky hand, and alternate slight rotation of the neck to right and left, producing the shaky head.

The tremors may be general or localized to any part; they are most noticeable and most inconvenient in the hands, partly from the long leverage given to any movement of the hand, which originates at the elbow, and partly from the interference with necessary actions. The tremors are often of the "intention" type, which is generally applied to those found in disseminated sclerosis, the excursion being increased during any attempted movement of precision the nearer the movement is to completion.

All degrees of the condition are found, and it is much increased by any alarming occurrence, such as gun fire.

Stammering is one of the commonest forms of inco-ordination found in war-neurasthenia, naturally enough, perhaps, since speech is a faculty requiring the co-ordination of several distinct muscle groups. The respiratory muscles must be working smoothly, the muscles of the larynx must be accurately co-ordinated with them, to produce phonation, and along with these must go the muscles of the tongue and lips on which articulation depends. The cortical centres for tongue, lips, and larynx are all very closely situated, and are, so to speak, evidently intended to act together, but, none the less, their several actions are often enough functionally disturbed.

Be that as it may, stammering is one of the commonest, and often one of the most intractable of disturbances of co-ordination. It is sometimes an aggravation of a pre-existing stammer, or a recurrence of a juvenile one.

It may be laryngeal, the larynx being kept closed and the breath not allowed to pass, which causes delay and struggle in starting speech, and sometimes the pitch is out of control, syllables are dwelt on unduly long, and the voice runs up the scale.

Sometimes it is chiefly articulatory, the patient failing to separate the lips for a "B," or the dorsum of the tongue and the palate for a "K," or else the letter can be made but is repeated an indefinite number of times.

Apart from actual stammer there is a peculiar speech which I have come to regard as characteristic of war-neurasthenia. It is low pitched, slow and monotonous, and it is "spaced," each syllable being given an equal value, with a pause between each; the sentiments conveyed are generally those of a depressed person, and are discouraging. "I—don't—feel—much—bet—ter—this—morn—ing," is the usual kind of remark. Stammering often occurs in patients previously mute, and often clears up completely in a day or two, sometimes as suddenly as the restoration of speech. In others there is gradual and maintained improvement, and this may be much assisted by treatment, which is of value in direct proportion to the trouble taken by the patient. Many cases of stammer are very resistant, and may continue unchanged for several months; beyond this I have no experience.

With regard to response to treatment, disturbances of co-ordination are far more intractable than those of paresis, which is remarkable since many cases of paretic spasm are more easily understood as cases of inco-ordination than otherwise.

Disturbances of motor system.—Contraction in excess, tonic and clonic spasm.

Both of these were curiously rare, only four cases of spasmodic contraction are recorded; all were cases of rigidity of one or both legs. Such cases have a good deal in common with inco-ordination since the rigidity is generally due to failure to relax the muscles which oppose the desired movement. The leg is held rigidly extended at hip and knee, generally extended and inverted at the ankle. Passive movements are fairly strongly resisted, and on a voluntary attempt at flexion the extensors harden and the spasm becomes slightly clonic. When walking is possible, the leg is held stiffly and circumducted. The condition differs only from that seen in civil practice in that it is recently acquired, and proportionally easily cured.

Clonic spasm, tic.—This again is uncommon. I have notes on only thirty cases, and these too differ only from those seen in civil life in their shorter duration; no particular treatment is required, in a large number of cases they subside in a few days. I regard it as ground for rather bad general prognosis; a large proportion of them occurred in severe cases, who were sent away quickly to base hospitals, very few were found fit to return to duty, and some of these were soon re-admitted.

Many different parts of the body were involved, head, face, eyelid, arm, shoulder, respiratory muscles, limbs, and "general." Seventeen cases cleared up, as to their tics, in a week or two, while several of the remainder were evacuated in a few days as severe cases. This is a much higher percentage of recovery than occurs in established tics treated in civil practice.

Contraction in defect.—Asthenia and paresis are much commoner than contraction or tic. Some degree of asthenia is the rule, it is part of the exhaustion following on the strain which is the exciting cause of the condition. I have found it evident enough to receive notice in 266 cases.

The commonest condition is simply one of objective weakness, inability to offer resistance to any strain on the limbs, as revealed by ordinary tests such as holding the fist up to the shoulder and resisting it being pulled away. When the weakness is not extreme, it is often obviously below what would be expected from the patient's physical development. Subjective asthenia, a feeling of weakness, is occasionally complained of, but an evident reluctance to make any effort and ill-maintenance of effort are the rule.

Paresis.—This occurred in forty cases, generally in the legs; paresis of the larynx with mutism is considered separately.

Paresis of the legs is generally an extreme condition of the reluctance noted above under "Asthenia." It is rarely complete, it does not often occur that a man is quite unable to move his limbs at all. He is, however, convinced that he has lost their use, as far as walking is concerned, and makes no effort.

The great majority are rapidly cured, most will walk back to their tents after one session of treatment. I remember none which were not at least able to stand. In some cases progress is slow and some defect in gait may persist for many weeks.

In a severe case the patient has to be carried to the examiner's tent. When lying in bed and asked to raise his legs, he can only lift up his foot a few inches. After some passive movements of the limb this improves, especially with encouragement. Asked to get up he generally protests his inability, and may have to be helped to a sitting position on the edge of the bed, and on to his feet. He lets his hips, knees and ankles give way, and subsides on the floor. With encouragement and insistence and some help he can generally be got on to his feet, but stands very unsteadily and clutches at support. It is commonly said that such patients only "fall soft" and do not hurt themselves, but I have seen some very heavy falls. When a patient can once maintain his balance the worst is over; with assistance and encouragement he can be induced to shuffle a few steps, provided you assure him that you will prevent him from falling. Care is required that not too much is done at any one session. If over-fatigued, patients are easily put back.

The commonest paretic symptoms are mutism and aphonia; there were eighty-five in my series. They are in nearly every case rapidly cured, a great many recover spontaneously, and the great majority in one session of treatment. There were four really resistant cases who took several days or weeks to cure, the delay was generally due to error in treatment, they were difficult cases which were undertaken by myself at the end of a heavy day's work, when I was fatigued and irritable, and became obliged to give up the treatment because I found myself losing my temper. If failure is once made, the difficulty of ultimate success is much increased.

Sometimes whispered speech is restored, but phonation delayed, and often the voice is out of control, running too high in the scale for some time. Stammering is common as a sequel, sometimes so bad that a patient is practically dumb. There were several cases which were rather aphasia than mutism, the patient learning to phonate and being able to repeat words, but unable to make any use of them. About one in eight of the mutes were also deaf, and if attention was given to the mutism by means of written instructions it was found that the hearing improved with the recovery of speech. As in cases of stupor a very partial success at any session may be followed by great improvement, next day. In the great majority of cases speech was restored in a single session of treatment, mutism is in fact one of the easiest symptoms to cure, and such cure has often something of the dramatic about it, but any claim to special merit put forward for any system of treatment based on its success in treating mutism should be heavily discounted.

VISCERAL SYMPTOMS.

Disorders of the great visceral systems are considered on the assumption that they are functional disturbances of the splanchnic division of the central nervous system. The arrangement is merely one of convenience, and is not intended to imply that any research work has been done to demonstrate any functional derangement of the heart or bladder which is strictly comparable to functional disorder of muscular movement or cutaneous sensation.

Circulatory symptoms.—237 cases.

These are considered under the headings of Subjective and Objective Symptoms.

The subjective symptoms are those most commonly found, and are chiefly vertigo, described variously as going "giddy," "dizzy" or "mazy"; præcordial pain, palpitations and dyspnœa. The vertigo is frequently worse on rising, and is occasionally severe enough to cause falling and even syncope. Præcordial pain, as noted under pain, is described as "shooting," "catching" or "a grip on the heart," it is generally localized about the left border of the heart.

Dyspnœa, doubtless often cardiac in origin, is referred to under the respiratory system. Subjective palpitation is occasionally noted.

The objective symptoms are tachycardia, cold, sweaty hands, cyanosis and blanching of the extremities.

Tachycardia is often very considerable; in my experience, it is not very often an initial symptom, but is developed in the course of a week or two. It is remarkable, since in this campaign, with all men inoculated against typhoid infection, the pulse rate is on the whole slow.

In war-neurasthenia it is generally high, but I make no claim to a systematic study of pulse rates. The following were noted:—

Case 35.—Rest, 128; short exercise, 168.

Case 36.—Exercise, (walking in tent, perhaps 10 yds. ; after five minutes' rest, 130.

Cases of pulse rate of 120 while merely attending an ordinary sick parade were very common.

An objective symptom, less frequently met with, but sometimes very striking, is a condition in which the hands and feet are cold, sweating and cyanosed. The typical picture of a patient suffering from war-neurasthenia, in whom the circulatory system is affected, is that of a generally depressed person, listless and uninterested, with a slightly cyanosed face, much cyanosis of the hands, which are a little swollen, chilly and moist, and a pulse rate on standing of about 120 per minute.

Several times a condition indistinguishable from Raynaud's disease has been found, in which the fingers and toes are quite blanched, cold and numb, occurring in patients who are not subject to anything of the kind. I have notes of eight such cases. They all improved at once with the wearing of woollen gloves, and cleared up in a few days; they appear therefore to be distinct from the cyanotic condition previously mentioned.

Respiratory symptoms.—104 cases.

The only respiratory symptom complained of is *dyspnœa*, either subjective or objective, doubtless it is sometimes cardiac in origin.

Subjectively it varies from a general complaint of shortness of breath on exertion or in excitement to that of definite attacks of asthma, often nocturnal, and associated with sensations described as "inability to speak," "gasping for breath," "wakes smothering at night," and an impulse to open the collar.

There is sometimes very striking dyspnœa, kept up for very long periods of some days, at any rate during waking hours, though I have no record of the condition during sleep.

In one case the general appearance of the patient strongly simulated that found in pneumonia, the breathing was counted at 120 per minute but with a pulse rate of 100. While under examination an aeroplane passed over the tent and distracted the patient's attention for a few seconds, during which the respirations fell to the ordinary rate. The dyspnœa gradually subsided and breathing was normal in three days. In another case respirations were counted at 80 and the pulse at 64 per minute.

Alimentary symptoms.—251 cases.

The alimentary system is frequently out of order in war-neurasthenia. The commonest subjective symptom is anorexia, and the commonest objective symptom is constipation. On the other hand, diarrhœa is not infrequent and it appears that the functions of the intestines may be upset both towards excess and defect.

Subjective symptoms: Appetite is frequently bad, there is general lack of inclination for food, "I don't care whether I have it or not," and often a meal is left unfinished, appetite rapidly failing. Thirst is occasionally complained of, and often during any prolonged examination or treatment the patient will drink greedily. Hunger, quite abnormal desire for food, is recorded twice. Loss of taste is recorded three times.

Nausea and dyspeptic pain are both fairly frequent.

Objective symptoms: Retching and vomiting occurred in about 10 per cent. of the cases with alimentary symptoms. Constipation is the rule. I have records in 35 per cent. of cases; three days' duration is a common period, and patients state that their bowels have not been open for five or six days or even longer.

Diarrhœa is recorded in 15 per cent. of cases. Small outbreaks of diarrhœa were rather frequent in the camp, and a large proportion of these patients were always affected.

Genito-urinary symptoms.—204 cases.

The only subjective symptom is pain in association with micturition, and this does not appear to be severe. Sometimes there is desire to micturate but no result.

Objective symptoms. Frequency is the commonest; it is chiefly nocturnal. Precipitancy leading to incontinence was found sixteen times, and nocturnal incontinence twice; it occurs in persons who were subject to enuresis in childhood. Several patients were asked to record the number of times they passed water in a day, a record which cannot be regarded as sworn testimony, but is still of some value. Some of the results are as follows:—

Twenty-nine times in twenty-four hours, passing 75 oz., sp. gr. 1008; twenty-three times in twenty-four hours, six times at night. (Five, four or three times are frequent.)

Infrequency is also common. These are instances:—

No urine for two days; micturition once in five days (alleged), once in two days, once a day, once in thirty-six hours.

The amounts of urine passed in twenty-four hours are also very variable. The following are recorded: 125 oz., 110 oz., 92 oz., 75 oz. and also 25 oz. and 15 oz. The contrast between excess and defect of the function of secretion of urine is very striking. As a rule there was no abnormality detected in the urine, and specific gravities were as a rule within normal limits, thus:—

125 oz.,	sp. gr.	1020,	no abnormal constituents.		
25 oz.	„	1012,	„	„	„
63 oz.	„	1015,	„	„	„
110 oz.	„	1018,	„	„	„

On one occasion sugar was found in the urine of a patient admitted stuporose; it disappeared on the following day.

Persistent seminal emissions were several times reported, and were generally rapidly reduced by the exhibition of iron and arsenic.

A few other symptoms were observed, which are not classified under any previous heading, of which the chief are free salivation and dribbling, sweating, and premature greyness of the hair and baldness; I have records of men going grey since the war began at the ages of 33, 29, 28 and 26, who were aware of no family tendency to this change.

PSYCHICAL SIGNS.—196 CASES.

The psychical symptoms observed in a general physical examination are only those of an obvious character, since systematic mental investigation is not carried out.

The chief thing complained of was lack of concentration, inability to read because the words mean nothing, and incapacity to write because the patient can find nothing to say; to write an ordinary letter to his own relatives is often an exhausting mental effort. One man was admitted a deaf mute, speech and hearing were restored in about half an hour, but he could only understand the simplest questions when spoken quite slowly; he said that he could hear words but that they conveyed no meaning to him.

Along with this, memory is often imperfect, though to a very variable degree. The following two cases showed positive amnesia :—

Case 37.—Lance-Corporal D., aged 20. Admitted March 14, 1917.

Appears to have no memory of events since playing cricket in August 1914. Has heard of Kitchener's Army, does not know of Lord Kitchener's death. Does not remember joining the Army. Surprised to hear he is in France.

March 15, 1917.—Remembers coming to France and being ill on board ship: the bombardment of Lowestoft; his Captain; the Esplanade Hotel; his mate being killed by an explosion; periscope, and seeing barbed wire.

March 19, 1917.—Remembers much more: Calais; farm-billets; marching order; dug-out; several men there, bombs falling and a man killed; had to bind up other men.

March 23, 1917.—Remembers enlisting September, 1914, 1/5th Beds., not taken to Gallipoli on account of nerves. Trained at Newmarket, Southwold and Holtham. Came to France January 1917, battalion seems to have been in rest till lately. Remembers going down communication trench, resting in dug-out till dark, and then going to bombing post in the dark; remembers bombs falling and some men being injured. Memory for immediate past very bad;

does not remember dinner to-day, and only recalls these events during conversation, otherwise mind is blank. Evacuated to base hospital.

Case 38.—Private N. Admitted March 13, 1917, semi-stuporose; said to have been unconscious for about a fortnight; no recollection of past events.

March 15, 1917.—Still only partly conscious, obeyed instructions in unintelligent manner, but improved much in intelligence during conversation. Remembers saying good-bye to his wife and child, but no recent memories.

March 19, 1917.—Remembers seeing his brother-in-law in uniform, who wanted him to join up, but he would not; also being a collier employed in an Admiralty pit, and so in a starred occupation, he could not do so: no knowledge of France. This man showed no further improvement before evacuation to a base hospital.

These cases are exceptional; as a rule amnesia does not amount to more than a blankness of mind about the occasion of the shock, and occasional lapses of memory, closely associated with inattention and lack of power to concentrate. Varieties of the condition are periods in which a patient "loses himself"; one man lost his sense of direction. Again attention to ordinary affairs may be interfered with by the fact that they cannot get their minds off the distressing circumstances they have been through, and this again leads sometimes to extreme depression, a sense of impending calamity, and a feeling "like going to certain death."

Loss of emotional control, exhibited chiefly by frequent crying, often occurs. Nervousness, alarm, much increased by anything recalling terrible memories such as gunfire, is the rule; sometimes it leads to complete loss of self-control and at times to impulses to murder and suicide, though no case of attempted violence has occurred in this series. Hallucinations are occasionally complained of: "sees shells bursting as he lies in bed," "unearthly things speaking in my head." One or two cases of acute hysterical mania have occurred.

Next to headache, bad sleep is the commonest symptom complained of. I have it recorded in 515 cases. Like headache, it does not bear investigation; when put under observation it is found that most patients sleep well after midnight. Sleep is, however, both delayed and broken, and disturbed by horrible dreams. Talking in sleep is often reported by others. Sleep is often said to be prevented by headache, and may be disturbed by hallucinations of sight, hearing and touch, and a feeling that the bed is on a see-saw. The following phrasing of complaints have been noted, "wakes not knowing where he is," "wakes shouting and cursing," "wakes trying to find something," "broken by a vision of his pal," "kept awake by worry." Somnambulism is rare. Occasionally (6 cases) patients complain of being unusually sleepy. It has to be remembered that these men are very listless and inclined to take every opportunity of sleeping by day.

PHYSICAL SIGNS.

Physical signs.—War-neurasthenia being essentially a functional condition, there are no changes in the shape, position or structure of the organs, and therefore there are no physical signs of the condition. There are, however, one or two points which may conveniently be referred to under this heading.

Tachycardia and the cyanosis, chilliness, and sweating of the extremities which occur in some cases of cardiovascular disturbance have been noted.

In the examination of the central nervous system some points about the reflexes require notice. No change was observed in the superficial reflexes, but the pupil was frequently found unusually wide, though it reacted to light. Deep reflexes showed an exaggeration of the variation often found according to the weather. This series of notes was begun in the winter, and throughout the cold weather the deep reflexes were found as a rule to be very brisk, in the usual functional way without any increase in tone; but during the hot weather of the summer the reverse occurred and it was often unusually difficult to obtain any deep reflex at all.

The sphincters, as noted under the alimentary and genito-urinary symptoms, are often disturbed both towards precipitancy and delay.

DIAGNOSIS, PROGNOSIS, TREATMENT.

Diagnosis.—The possibilities to be excluded are the following:—

(1) *Organic disease of the nervous system* and *insanity* which between them amounted to about 5 per cent. of my series, and included hemiplegia, paraplegia from fracture-dislocation of the spine, disseminated sclerosis, tabes dorsalis, traumatic peripheral nerve injuries, meningitis, peripheral neuritis, epilepsy, dementia paralytica, dementia præcox, mental defect and feeblemindedness.

My thanks are due to Captain Evans, who has experience both as an alienist and with the feebleminded, for his help in these cases.

(2) *Intercurrent disease*, of which trench fever (recurrent pyrexia and shin pains) is perhaps the commonest. It is an infection very widely

spread among troops, and one guesses that shock and strain predispose to recurrence in persons once infected. The pains are not uncommon without actual pyrexia, and it is not unlikely that trench fever accounts for a good deal of the pain complained of in war-neurasthenia.

(3) *Malingering.*—This, in the sense of deliberate simulation of symptoms, is in my opinion very rare. Exaggeration of course is common enough, and no doubt the purely subjective symptoms, such as headache, are often worked for a good deal more than they are worth. There is no guide that I know of beyond reports of different behaviour when a man is at sick parade and at other times. Against it all one has to put the fact of the enormous strain to which a man knows he is going back, after having previously broken down under it, and I am convinced that many men are speaking no more than the truth when they say that they do not feel fit to rejoin, although they would doubtless be fit enough for many forms of employment, provided they did not involve further exposure to conditions of warfare. But the large proportion of patients who are returned to duty without any difficulty indicates the absence of any real malingering.

(4) *Dislike of military service.*—This is a condition in many ways distinct from malingering, and I can only judge of it from hearsay. It is that of men who become distressed and alarmed in action, and on the first opportunity report sick in hopes of being sent out of the line, although they have undergone no real shock, and have not been sufficiently exposed to acquire war-neurasthenia. The sequel depends entirely on the battalion medical officer, for if a man finds that by making fuss enough he can get sent out of the line, he will make the first instance a precedent, as soon as he is returned to duty, and his career as a fighting soldier may be considered closed. Nothing can be done to deal effectively with such cases in hospitals; the matter rests entirely with the officers of their units.

Prognosis.—This, so far as it can be given, is based entirely on figures. There is no more to say than that so many patients became sufficiently well in hospital to be returned to duty, within the prescribed period of a month, and that so many others did not.

All patients admitted, and their disposal, are here set out in tabular form.

The competition between various centres, and rival methods of treatment for the return of patients to their units is a most vicious procedure in the treatment of functional disease, where there is no visible lesion, and symptoms are so largely subjective. With cases of fractured femur a successful surgeon has cases of good union, absence of shortening, and general serviceability of limb to show, but cases of neurasthenia who are beginning to recover look very much like normal people, and can be sent to their units, when they count as "cures," although they may only add to the paper strength of a unit and readily relapse on exposure. Still, there is no other means of forming an opinion as to prognosis than that yielded by figures.

Of 1,300 cases 354 were either organic or had some intercurrent disease, or grave visceral symptoms, such as persistent incontinence or disordered action of heart, and since no female nurses were employed at this unit, and facilities for the comfort of seriously ill patients were few, the great majority of these (303) were transferred to other hospitals.

There remain 946 cases of uncomplicated functional nervous disease; of these 612 were "acute" cases of sudden onset, and 334 of gradual onset. Methods of discharge were the following:—

A. to duty with their units, generally with a recommendation for light duty for a period of a month.

B. to base duty, employment away from army areas.

C. to convalescent camp, for ultimate discharge to duty. This channel of discharge was only available towards the end of the period under consideration.

D. to base hospitals.

Discharge to	A	B	C	D
Acute cases, 612	307	104	103	98
Percentage	50 %	17 %	17 %	16 %
Gradually acquired, 334	68	140	44	82
Percentage	20 %	42 %	13 %	25 %
All cases of uncomplicated functional nervous diseases, 946	375	244	147	180
Percentage	40 %	26 %	15 %	19 %

That is, of all cases about 40 per cent. went direct to duty, about 40 per cent. to light duty or prolonged rest previous to duty, and about 20 per cent. to base hospitals.

Of the acute cases 50 per cent. went to duty, 34 per cent. to light duty, 16 per cent. to base hospital, and of the gradually acquired conditions 20 per cent. to duty, 55 per cent. to light duty, and 25 per cent. to base hospital.

There are, of course, right ways and wrong ways of treating these patients, but I look upon these results as being due chiefly to the natural recuperative power of healthy men given a reasonable chance.

I have records of forty men sent to duty who broke down within the next few months, but I have no doubt whatever, from what I have seen of relapsed cases treated in other centres, that there were many others. You cannot treat a man so well that you can guarantee him against relapse, but you can very easily send him up in an unfit condition. Nobody's judgment is perfect, and everybody will make mistakes in plenty, but, with the existing demand for men in the combatant units, it has been the duty of medical officers to risk error rather in the direction of sending up possibly unfit men than in that of losing possibly fit men to their units.

Treatment.—War-neurasthenia has been defined above as a condition of fatigue with loss of emotional and physical control. It thus contains physical and psychical factors, and the same principles of treatment are applicable to both.

The obvious treatment of fatigue and loss of physical control is rest and graduated exercise, and the same general idea is carried out psychically by removal from the causes of the condition, the maintenance of discipline and graduated mental occupation.

The general method employed with the cases was as follows: It was to be understood by the patients that they were not invalids in the ordinary sense, they were not ill, they had no wounds, no infection, nothing wrong with heart or lungs or other organs; they were merely strained and exhausted, and would soon recover. The graver cases were kept in bed for a few days—as a rule, not more than one—for a short complete rest, a dose of bromide of potassium was often given at night. This rest was not continued more than a day or two on account of the impression of invalidism given thereby, for many of the patients have "thrown down their cards," and are quite ready to accept the rôle of invalids. This is particularly the case with paretics who have lost the power to walk, and, naturally enough, think that they have lost it altogether, a sufficiently depressing thought. When such cases are got up, and made to walk and realize that they are not cripples, the improvement in their condition is often strikingly rapid; the same is true of a mute when he finds himself restored to human fellowship.

A sick parade was held daily at the medical officer's tent, which all patients attended on alternate days; this was the first step towards convalescence. The men were then employed on light fatigues about the tents, next attended physical drill under a trained instructor, next went out for route marches about the country, and finally moved to the convalescent section, which provided working parties for the heavier fatigues required about the hospital. This was a fairly satisfactory general arrangement from the physical point of view, and worked pretty well; psychically it was incomplete. In this, as in the treatment of all other conditions, the prime necessity is the removal of the cause, and where people have broken down from exposure to shell-fire it is correct treatment to remove them to an area which is free from shell-fire and bombing raids. The setback which ensues on a hostile air-raid is very striking, the difficulty of maintaining discipline is extreme, and an excuse is provided for all who are inclined to exaggerate their symptoms. The Adjutant-General's branch, however, decided to keep these cases in centres in Army areas, which has added very greatly to the difficulties of their treatment. On the other hand, if the return of patients to their units is contemplated, it must be clearly understood throughout the hospitals that this is to be the case, and centres are not easily worked at bases on the coast, where the cliffs of England are easily to be seen, and from which patients are constantly being evacuated home. Neurasthenics, who have had their belly-full of fighting and have no desire to do any more, when they once find their condition has brought them to the base are likely to have continued subjective symptoms under these circumstances. The most suitable places for the treatment of cases likely to be fit to return to duty would be inland sites in France, altogether out of reach of bombing raids, and quite out of the way of artillery ranges, trench mortar schools and the like. Such not being available the best has to be made of what is to be had. One very common cause of psychical distress is domestic worry, such as the health of wives, the death of children, whom the fathers have sometimes never seen, the poverty of parents, the death in battle of brothers and intimate friends, and the occasional infidelities which are inevitable in long periods of marital separation. This of course opens up a very large question, that of leave, which has consequences far beyond the medical, but it has a very direct bearing both on the incidence and the recovery of cases of war-neurasthenia, and on the rare occasions when it is possible for a patient to obtain leave the opportunity should not be missed.

Discipline, however, should be very strictly maintained, and no kind of slovenliness permitted, but harshness is a thing altogether to be avoided. I have seen a large number of patients who were doing fairly well until they came under an officer who frightened them, and gave them the impression that he was bullying them, when they went to pieces. This is particularly the case with men suffering from defects in co-ordination, tremors and imperfect gait. At the same time, firmness and even severity are essential with patients who will not make the necessary effort, and are ready with plausible excuses, and the distinction between severity and harshness is a very nice but a very real one. It can hardly be set down in words, but the guide is this: whatever gives you improvement, whether kindness or severity, is right; whatever puts your patients back and does not get them on is wrong, encouragement is always necessary. The matter of occupation is a difficulty; men ask for "anything to occupy my mind," but actually cannot maintain interest for any long period. The best results are given by getting men to work at their own skilled trades, carpentry, sign-writing, and gardening and the like, but it is difficult to get enough interest taken in ordinary "fatigues" for them to have much curative value. Concerts and cinema entertainments of an elaborate character are not of great value; patients frequently do not care for them, their headaches get worse and they come out in the middle. The best are those in which the patients take part, or which they arrange. Much might doubtless be done by personal interest in devising games, entertainments and occupations generally, but of this I have little experience from lack of the necessary gifts.

A matter constantly discussed in the psychical treatment of neurasthenia is suggestion; it is commonly said that the patients are suggestible in a high degree, and that hypnotism is of especial value. I do not employ hypnotism, and, having no experience of it, I have no criticism to offer upon it. In the treatment of the physical disorders of war-neurasthenia, which is the subject of this paper, it is chiefly of value, from what I am able to learn, in hysterical cases, but from the ease with which hysterical symptoms are treated by other methods I think it can rarely be necessary. I gather that in the inco-ordinate cases, which are the difficult ones, hypnotism is of little avail. But hypnotism apart, what is meant by the word "suggestion"? It appears to me to be used in medicine, perhaps unconsciously, in a sense quite foreign to that in which it is used in conversation. The word is used colloquially in such senses as the following: "I had suffered for a long time from abdominal pain, my doctor *suggested* an operation." "An apple falling from the tree *suggested* to Newton the theory of gravitation," "A scientific paper full of *suggestive* ideas." "I was continually missing money; he *suggested* that I was being robbed." All these uses of the word imply putting a new idea into your head, upon which you may on your own initiative take independent action. They imply that your mind was a blank on the subject before, not that you were seeking information on which to take action; if the doctor suggested an operation, you had not thought of it before, but expected medicine to be sufficient treatment.

But the word "suggestion," as applied to the treatment of functional nervous symptoms, is used so as to convey an impression of the occult. Its practitioners are supposed to possess a mysterious power which is out of the reach of common men, an influence on others' lives to which few can pretend. Whether this is deliberately cultivated or not, I do not know, but it is the idea which exists in the public mind. Patients with functional symptoms come for treatment, and in some subtle fashion it is introduced into their minds that the power they thought they had lost is really present, and thereby the symptoms are relieved. It is also stated that neurasthenic patients are more suggestible than other people, and some curious examples of this are given. I have heard of a patient who came to hospital with a long list of symptoms entered on his field medical card; his medical officer read these, and, intending to chaff him a little, said: "By Jove, you seem to be in a pretty bad way," and was then called away. On his return he found the patient in the lowest depths of depression, his remarks having been taken quite literally. And this is an instance of suggestibility. It appears to me that it was merely expert confirmation of the patient's worst fears; had he had a sore on his tongue, and been told that he must undergo an immediate operation for excision, and been proportionately depressed, it would have been thought perfectly natural; the two cases seem to me exactly parallel.

Personally I do not think neurasthenics are more open to suggestion than anybody else, but they are in the main depressed, and their depression is increased if, when they come for information about their condition, that information is of a depressing character, and they are cheered up if the information is cheering, in which they behave in precisely the same way as other people. I propose, therefore, to omit suggestion as a point of great importance in the treatment of the physical symptoms of war-neurasthenia, regarding the term as a misnomer for the kind of psychical influence required. Apart from mere passage of time, and natural recuperative processes, these patients recover their lost faculties through their own efforts, and the necessary attitude of the medical officer is one of encouragement. This attitude is required throughout, but, perhaps, most conspicuously in the treatment of hysterical symptoms, paresis and anæsthesia; and encouragement is, in my opinion, far more effectively given by way of demonstration than by way of suggestion. The difference is this: "You think you cannot walk, but I now put it into your head that you can," as compared with "You think you cannot walk, follow my instructions; observe you are walking." Exponents of hypnotism have told me that this is suggestion; I am unable to see it. In a case of anæsthesia the patient cannot feel ordinary stimuli, but he can feel stimuli sufficiently strong; when, therefore, I apply a powerful faradic current which he does feel, and after this ordinary stimuli are appreciated, I realize that the patient has had his capacity to feel demonstrated, but I fail to see that suggestion has anything to do with it. I am also unable to support the view sometimes expressed that the hysterical symptoms themselves are due to the suggestion of the doctor.

I have laboured this point somewhat because it seems to me important that those who have to treat such cases should not spend their energies on a misconception, when they have an efficient means of treatment to hand all the time: let them try demonstration.

The treatment applicable to several symptoms was stated when they were described, and are here recapitulated for the sake of completeness.

Pain is better relieved by physical appliances than by drugs. Heat, cold, fomentations and hot-water bottles, icebags and compresses, massage and blisters are all of value. For headache, the pillows should be packed at night, change of position should be made slowly, and in severe cases lumbar puncture may be considered, and headache due to spasm of accommodation may be relieved by atropine.

Anæsthesia of the skin and deep tissue may generally be left alone; if obtrusive, faradisation sufficiently strong to be felt should be employed.

Special senses, blindness and deafness. No cases of the former occurred in this series, but in a case reported to me from the ophthalmic department, vision was restored under examination with the ophthalmoscope, that is, by application of highly concentrated light to the retina.

Deafness often recovers spontaneously; loud unexpected sounds, such as a bell rung behind the head, and also the concentration of sound through the stethoscope often restores hearing; in deaf mutes the recovery of speech is of great assistance.

Defects of co-ordination, tremors and stammers. These are among the most difficult troubles to treat, where they are persistent and do not subside spontaneously.

For tremors, re-education, the performance of controlled movements under supervision, is of service, and perhaps the best results are obtained you cannot walk, but I now put it into your head that you can," as compared with "You think you cannot walk, follow my instructions; observe you are walking." Exponents of hypnotism have told me that this is suggestion; I am unable to see it. In a case of anæsthesia the patient cannot feel ordinary stimuli, but he can feel stimuli sufficiently strong; when, therefore, I apply a powerful faradic current which he does feel, and after this ordinary stimuli are appreciated, I realize that the patient has had his capacity to feel demonstrated, but I fail to see that suggestion has anything to do with it. I am also unable to support the view sometimes expressed that the hysterical symptoms themselves are due to the suggestion of the doctor.

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After this, the patient is to count up to ten, and after that he is asked to answer simple questions, such as name, number, regiment, service, civil employment and the like.

He may then pass on to repeat some familiar consecutive passage, such as the "Lord's Prayer."

For all this you require the patient's fullest attention, and must give your own. The treatment should be given in a separate room; if this is impracticable the end of a ward should be cleared of other patients and screened off. Patients are shy of exhibiting their disability, and you will not get them to do their best until they realize that you are entirely in earnest and will not allow them to be made ridiculous in any way.

Paresis.—You have here to demonstrate to the patient that he possesses the power which he believes himself to have lost.

The commonest form of paresis is that affecting the legs, with inability to walk; it is rarely so extreme that no movement at all is possible.

The patient should lie in bed, with the legs stripped. Examine the joints, muscles and reflexes to exclude organic disease. Hold your hand about 18 in. above his ankles and tell him to touch your hand with his foot: he will probably raise his foot a few inches, and if he fails to touch your hand, pick up the legs and move all the joints passively through their normal range, and tell the patient to repeat the movement; there will probably be some improvement, encourage this at once by praise. Lift your hand higher, and help his movement by lightly slapping the calf with your other hand. Stick to every movement till it is performed. In resistant cases great help is given by faradization: the symptoms are due to the fact that the patient cannot of his own unaided volition transmit the necessary impulse to his limbs. The cutaneous stimulus arouses him to make the necessary effort. Many patients are very frightened of the battery, and in these cases it should be applied at first quite weak and gradually increased, till it is strong enough to produce the required result.

Having demonstrated that the patient can move his legs naturally, the next thing is to get him on to his feet. Tell him to rise to a sitting position on the edge of his bed, helping him if required. He will probably be unable to get up on his feet, but will make some effort; help him as much as is necessary, but as little as possible. Once on his feet there is a general inclination to collapse and subside on to the floor, and here strong insistence is required; if he falls, you must pull him up at once. He must be instructed to stand on a wide base, with the feet about 15 in. apart, and to stiffen the knees; in most cases he will gain his balance in a minute or two, he will stand unsteadily, but still he will stand. Point this out, and encourage him. Now stand facing him and hold his hands, assure him that you will not let him fall, and make him take a step towards you, insisting and encouraging all the time.

If progress is not rapid, stop and apply the battery again, and repeat. Demonstration, insistence and encouragement are required the whole time. When he begins to walk, walk backwards yourself in front of him to give him confidence, any attempt to subside on to the ground, or to totter backwards can generally be checked by sharp insistence. I remember no case that was not able at least to stand after a single session of treatment, and the great majority were able to walk back to their tents. It is important not to overtire these patients, many are put back by doing too much at first; it is essential to exercise them every day, each day doing a little more than previously. It may take weeks before there is complete restoration, and the earlier the case is taken in hand the better the prognosis.

Monoplegias are treated on similar lines.

Mutism.—This sometimes clears up spontaneously, and all degrees of difficulty are found in curing it; some patients have merely to be shown how to speak, and recover at once, others may take hours.

I have used the following plan of treatment.

Sit face to face with your patient, ask him to speak; he will indicate that he cannot do so but will show readiness to write; do not allow him to do this. Ask him to cough, the majority can do so quite easily; assure him that if he can cough he can speak, because it is using the same part of his throat. Then tell him to cough, and as he coughs say "A"—cough out "A." This is often successful at once, or in a few minutes. If there is delay or resistance, the battery is again very useful in stimulating to the necessary effort. I generally apply it to the upper part of the chest. If phonation presents great difficulty whispering is often practicable. Seize upon whatever the patient can do, and work up from that. As in all symptoms of the kind, insistence and encouragement are of the first importance.

When some phonation or whispering is possible, take the vowels and then the consonants as suggested under the treatment of stammering. It will often be found that in repeating any sequence like the vowels the voice rises higher and higher in the scale, but this subsides in a short time.

When whispering is correctly done, but there is difficulty in phonation, and it is not restored by the battery, it is often of service to use the laryngoscope. The presence of the mirror at the back of the throat often supplies the required stimulus; if necessary the laryngeal electrode may be used.

For visceral symptoms of severity there is very little to be done under the conditions prevailing in the neurological centres.

Cases of tachycardia were as a rule transferred to a special centre established for such patients, where they were treated for disordered action of the heart on principles of graduated exercise, with a large proportion of good results.

Respiratory symptoms require no special comment.

The alimentary symptoms, anorexia, nausea, vomiting, dyspepsia, constipation and diarrhœa, are to be treated on the usual lines by diet and the usual medicines. I have found none of any special value, and on the whole these patients are very insusceptible to drug treatment, the symptoms varying with the general condition.

The genito-urinary symptoms are equally resistant; a few cases of precipitancy and incontinence appeared to be benefited by bromide of potassium and tincture of belladonna, but by no means all. Seminal emissions seemed definitely better after the administration of iron and arsenic.

Several drugs have been tried for sleep. I have found no specific, but one or other of the following generally gives improvement: Potassium bromide, up to 30 gr.; potassium bromide, 15 gr.; chloral hydrate, 15 gr.; tr. opii, 15 ♏; paraldehyde, best given in half-drachm doses; trional, 10 gr.

But the essential treatment for the whole condition is initial rest, graduated exercise and occupation.

Hypothesis as to organic basis of functional nervous disease.—No one can be in contact with functional nervous disease for any long period without inquiring why the symptoms occur. What is the difference between a man's nervous system before and after he has developed neurasthenia, accepting the assumption that no visible change occurs? I was aware of one physiological fact which had some bearing on the question, namely, that in an animal under the influence of fear there is an increase of sugar in the circulating blood. This was explained on the assumption that in fear something is perceived in the environment for which a violent muscular effort is required, either for the purposes of combat or escape, and that there is a physiological means of providing an additional supply of sugar, as fuel for the muscles, to enable this effort to be made. I was aware, further, that the increase was believed to be due to the activity of the adrenal glands, acting under the influence of the sympathetic system.

I wished therefore to find out how far the ductless glands might influence the condition of neurasthenia, but I had no facilities for research in this direction, and such published works as were accessible to me were of no assistance. Beyond finding sugar in the urine of a severe case of shock I had no data bearing on the subject.

On one occasion, however, the hospital was visited by Major Crile, of the U.S.M.O.R.C., the well-known authority on shock, with whom I was able to discuss the matter. Following up his suggestions, I have attempted to construct an hypothesis to explain the symptoms of neurasthenia. I do not wish to father these views on to Major Crile, as they are merely conjectures which have occurred to me as the result of his remarks. The thing, as far as I am concerned, is pure guesswork, unsupported by experiment, but would, perhaps, be worth experimental investigation.

The idea, at any rate, is as follows: Life depends on adaptation to environment, and in the higher animals the function of adaptation is discharged by the nervous system, consisting, as it does, of organs of sense, afferent nerves, centres and efferent nerves, which end in muscles. Adaptation consists in the reception of stimuli from the environment by the organs of sense, their interpretation at the centres, and the performance of appropriate movement by the muscles. Its simplest instance is the pure reflex, as, for instance, the contraction of the pupil, which is the adaptation of the eye to the environment of light; it is unconscious and involuntary, and cannot be prevented by the will. Closely allied to this, but depending on consciousness, is instinct, using that word to express impulses to action, which have to do with the preservation of life. A primitive instance of this is flinching from pain; if you accidentally touch a hot stove, you instinctively but consciously withdraw your hand; it is a conscious, instinctive impulse to action for the preservation of your person. Comparable to this, although more complex, is the instinct to escape from danger, as when a soldier sees bursting shells, recognizes these are dangerous to life, and feels the impulse to get to a place of safety. But we are not moved only by reflex and instinct; we are moved also by emotion, which I do not here attempt to discuss, and by reason. Reason depends on previous experience and training, and hence on memory; it is an impulse to selected action, to secure an ultimate object, which obedience to instinctive action might imperil, and, consequently, for reasoned action, such actions must be controlled. The desire to escape from danger is inevitable, although of variable intensity in different individuals, but the muscular movements necessary to discharge such action may not be allowed to take place.

It is suggested that herein lies the physiological basis of neurasthenia. Major Crile's views, if I have understood them, are somewhat as follows: When anything appears in the environment which is recognizable as a source of danger, impulses are received and interpreted by the brain, but those impulses cannot pass from the sensory to the motor side of the brain, and so induce action to be taken, except in the presence of secretions from some of the ductless glands, of which the adrenal is probably one. On perception by the sensorium of the alarming object, impulses pass to the adrenal by way of the sympathetic, and induce it to secrete, and when this has occurred impulses can pass to the motor side of the brain, and appropriate action can be taken. Evidence of this action of these glands is the hyperglycæmia and occasional glycosuria which are found among these cases. Now a soldier under discipline has to suppress his instincts and act according to reason, the ultimate result to himself and his side of obeying his instinct to escape being much worse than if he kept his instinct suppressed. But that will not stop his ductless glands from working, and it is suggested that war-neurasthenia, the exhaustion, fatigue, loss of control, and visceral disturbances are due either to exhaustion of, or intoxication with, the products of the ductless glands, which have been under constant stimulus, but whose products have not been properly metabolized by the actions they were intended to facilitate.

I do not propose to consider the bearing of this on emotion, but tears, the excessive secretion of the lachrymal glands at distressing sights, and mouth watering, profuse secretion of the salivary glands in the anticipation of food, are instances of obvious glandular secretion on the perception of particular circumstances in the environment, and I suggest that the symptoms of war-neurasthenia may be referable to either over-stimulation or exhaustion of the ductless glands, especially the adrenal.

In support of this, Starling states that the injection of adrenalin arouses every activity that can be normally excited by the stimulation of the sympathetic system, and the chief results of stimulating the sympathetic are the following: Vaso-constriction of the blood-vessels, dilatation of the pupil, increased secretion of sweat and saliva, acceleration of the heart, vaso-constriction of the intestines and kidney, vaso-dilatation of the same, inhibition of the intestines, contraction of the ileo-colic sphincter, and inhibition of the bladder.

Compare with this list the following symptoms noted in this paper, dilatation of the pupil, occasional sweating and salivation, tachycardia, the frequent occurrence both of constipation and diarrhœa, and the remarkable variations between polyuria and suppression. So far, therefore, as general clinical observations can support any such hypothesis, I think the experience gained from these cases goes to support the view that the symptoms of war-neurasthenia are due in part, at least, to prolonged over-stimulation of the ductless glands, chiefly the adrenal.

CONCLUSION.

No one can spend a year in charge of cases of war-neurasthenia without being convinced of the reality of this condition, of its severity and of its amenability to treatment. What the nature of the change produced in the ductless glands, if any, may be I have no idea, but I am convinced that it requires a long time for recovery, and I doubt if anyone who has once developed it will ever be fit for front-line soldiering within the time limit of any war. In cases primarily due to shock there is probably little change, and many men get quite fit for service. I do not think there is any means of testing this except by returning men to their units, when many are able to carry on, though they are not the men they were. After a second breakdown I think it is useless to send men up again, they are only adding to the paper strength of battalions and are quite unreliable in any stress, and probably do little but harm in showing a bad example. It is the duty of all medical officers to set sentiment aside and have nothing in mind except the fighting strength of the Army, but it must be the fighting strength. Record nursing, which claims to return to the line a greater percentage by two or three than the man at the next Army Centre, is a procedure in my opinion wholly to be deprecated, however much favour it may win with the administrative staff.

I would put in a very serious plea for a thoroughly sympathetic and intelligent grasp of the problem on the part of the higher medical authorities. It is not every doctor who knows how to treat functional nervous disease; he requires training for it, just as he does for taking out teeth. The most influential man with whom the potentially neurasthenic soldier comes into contact is the battalion medical officer. Of this I am convinced, although I speak only from hearsay. Records of cases sent down as "shell-shock" or "neurasthenia" by different medical officers differ enormously; the few who know anything of nervous disease appear to have far the smallest numbers. A man who has the knowledge to recognize the man who merely dislikes it, and the character to send him back to the line, saves numberless soldiers and is of immense disciplinary value. Further, such a medical officer can pick out men who are beginning to get shaky and keep them under his own eye as orderlies or stretcher-bearers, and thus save many more, and his services are invaluable in dealing with a man returned to duty from hospital.

In the centres themselves it is of the first importance that a sufficient number of officers who know their business should be selected for the treatment, and that training to that end should be instituted. Preferably whole hospitals should be devoted to the work. Much more complete courses of treatment are required for patients who get past the centres. A man with a broken thigh receives, as he should, adequate supervision till he is well again, but the chances are much against his doing any further service. If these patients, with their tremors and stammers are allowed to drift, as they will unless it is somebody's business to see after them, a condition remains untreated which is at first curable, but rapidly becomes intractable and is then a serious disability for civil life.

My plea is for men whose disabilities are as real and as creditable as any wound, and for work which can only be undertaken by men properly educated, work which is tedious and exhausting, but which is of serious national importance, and which gives results.

HYPERGLYCÆMIA IN MENTAL DISORDERS.

BY DR. F. H. KOOY.

(*Psychiatrische-Neurologische Kliniek, Groningen, Holland.*)

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INTRODUCTION.

It has long been known that emotions, especially those of a depressive nature, have a bad influence on the course, if not on the origin, of saccharine diabetes.

In 1674, Thomas Willis wrote the following words, to which posterity has but little to add: "Interdum moeror & tristitia diuturna, item affectus convulsivi, aliaque spirituum animalium depressiones, ac mordationes, diathesin hanc morbidam parere aut fovere solent."

All who have since worked on diabetes agree on this point, that emotions, such as fear, trouble, anxiety and anger, often aggravate the illness (Senator, 1879; Frerichs, 1884; Naunyn, 1906; Lépine, 1909). Von Noorden (1917) also admits that emotions bearing a depressive character may cause an increase of glycosuria, though he does not believe in the nervous origin of real diabetes. For nervous glycosuria is based on hypersecretion of adrenalin, and diabetes mellitus is according to him a dyspancreatosis.

In the second place it is a remarkable fact that some persons, who are in a state of agitation, especially those of a neuropathic constitution, show a temporary excretion of sugar. They do not suffer from diabetes before, nor do they acquire it in the course of further observation. Of course, a good many of the patients, who show transitory glycosuria, appear to suffer from real diabetes in later years (von Noorden), but some of those cases can only be interpreted as examples of nervous glycosuria (cf. Goodhart, 1889; Flesch, 1891).

Thus we often observe glycosuria on the first day of admittance to hospital, although it cannot be found afterwards.

Ricci (1908) found transient glycosuria six times in fifteen cases, after the necessity of an operation was first communicated to the patients. Follin, Denis and Smillie (1914) found glycosuria after difficult examinations; the same was observed by Cannon and Fiske (Cannon, 1918, op. cit., p. 75) with excited spectators of a football match. Glycosuria in cases of grave psychical alterations are also well known; they are mere instances of the same kind of nervous glycosuria. I do not speak of cases of anatomical cerebral lesions, such as hæmorrhages, tumours, meningitis, &c., or even of dementia paralytica, but I refer to the merely functional psychoses. The fact that glycosuria is so often observed in melancholia was the starting point for my researches. I must refer to the first chapter of this paper, where this question is discussed in extenso.

I take it for granted that emotions of a depressive nature may cause glycosuria in man. Intentionally I do not speak of diabetes, but only of glycosuria. Now glycosuria may have two causes: either the amount of blood-sugar is too high (hyperglycæmia), or the kidneys allow the sugar to pass, though the percentage of sugar in the blood is normal (renal diabetes).

A priori it was probable that nervous glycosuria was caused by hyperglycæmia, for the kind of experimental glycosuria which is doubtless the consequence of an affection of the central nervous system—the famous "piqûre" of Claude Bernard (1854-1855)—depends on hyperglycæmia. The same is the case with the puncture of Aschner (1912).

Glycosuria after injection of diuretine, a caffeine derivate by which the nervous centres are stimulated, is also based on an increase of sugar in the blood (Rose, 1903; Nishi, 1909).

In both experiments ("piqûre" and injection of diuretine), glycosuria is brought about in the same way. That this glycosuria was totally dependent on the amount of glycogen in the liver was already demonstrated by Claude Bernard and affirmed by all authors who afterwards worked on this subject (see also Pollak, 1909). The stimulus in question, however, does not go directly to the liver, at least not exclusively, for glycosuria could not be procured, if the splanchnic nerves had been cut (Claude Bernard, 1877; Eckhardt, 1869), if both the suprarenal glands had been removed (A. Meyer, 1906, 1908; Kahn, 1911), or if those glands had been deprived of all possible innervation (Nishi, 1909; see also the experiments of Macleod and Pearce, 1911).

According to these various experiments, we have formed the following conception of the mechanism by which glycosuria is produced by "piqûre" and diuretine diabetes. From the central nervous system the stimulus is conducted by the splanchnics (principally the left; Nishi, 1909) to the suprarenal glands; this leads to hypersecretion of adrenalin, which is brought into circulation and reaches the liver, where more glycogen is mobilized. In consequence of this, more glycose is found in the peripheral blood (hyperglycæmia), and if the amount of sugar be high enough it can also be found in the urine.

That indeed splanchnic stimulation causes an increased secretion of the suprarenal glands was first demonstrated by Dreyer (1899) and confirmed by later observers, e.g., by Asher (1912, 1917); the secretion of adrenalin was proved in these experiments by its characteristic influence on the blood-pressure. (See for an account of the literature on this subject Cannon, 1918, op. cit., pp. 41-43.)

Waterman and Smit (1908) found an increased percentage of adrenalin, not only after faradization of the suprarenal glands, but also after the "piqûre" of Claude Bernard, by testing the mydriatic power of the blood, drawn from the vena cava above the entrance of the adrenal veins on the pupil of the frog. These results could not be obtained by Kahn (1908) and Nishi (1909.)

That glycosuria, merely dependent on emotion, has quite the same mechanism as the "piqûre" and diuretine-diabetes was shown by Cannon, Shohl and Wright (1911). When a cat was extremely excited by a barking dog glycosuria appeared, whereas the urine was found without sugar before and after the experiment. By extirpation of the suprarenal glands this glycosuria could be prevented.

Cannon and De la Paz (1911) have also demonstrated by the same experiment that emotion causes an increase of adrenalin in the blood of cats.

The experiments by Elliot (1912) on cats by means of injections of β-tetrahydronaphthylamine hydrochloride form a valuable affirmation of Cannon's results. β-tetra gives a typical emotion of terror, and at the same time a decrease of adrenalin in the suprarenal glands, which could be prevented by cutting the splanchnics.

That emotional glycosuria in cats[1] is based on hyperglycæmia was proved by Scott (1917); emotional hyperglycæmia was also demonstrated in rabbits and dogs by Hirsch and Reinbach (1913, 1914), Bang (1913, No. 15) and Loewy and Rosenberg (1913, No. 121).

So we may take it for granted that both the "piqûre" diabetes and the so-called emotional glycosuria are based on hyperglycæmia, and that the latter is effected by a hypersecretion of adrenalin.[2]

It is impossible to mention all who have worked and experimented on the subject in question; I was, however, obliged to discuss the principal facts shortly, which led me to the investigations which I am now about to mention, facts which are moreover necessary in order to understand the significance of my results and the explanation I intend to give of them.

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[1] This was first found by Bohm and Hoffmann (1878) in their experiments on "Fesselungsdiabetes," but it was not correctly interpreted until the publication by Cannon.

[2] That injection of adrenalin produces glycosuria was found by Blum in 1901, and confirmed by nearly all the authors who afterwards studied this subject.

CHAPTER I.—RESEARCHES ON BLOOD-SUGAR.

Method.

It would lead me too far to discuss in extenso the technique of my researches. I used the method of Bang as described in his second publication on the subject (1916). The pressure of gas being very inconstant in these abnormal times, after an unsuccessful trial of four months, I used an electric boiling method, by which I obtained reliable results.

Instead of acetas uranylicus, I used nitras uranylicus, which is much better soluble.

As chloretum kalicum purissimum of Kahlbaum could not be had owing to the war, I used the same salt unpurified; I could not therefore use Bang's formula and was obliged to make my own standard, both for the self-reducing power of the solution of chloretum kalicum, as for the reducing power of solutions of 1, 1·5 and 2 per mille glycose.

In order to control my solutions I repeated these examinations every now and then and I always did so every time I used fresh solutions. During the first month of my researches I carried out every investigation twice, until I was sure of making no mistakes of any importance; afterwards I did so occasionally only.

At first I only examined the blood before the patients had broken their fast, but afterwards I also looked for alimentary hyperglycæmia, examining the patients before, and three-quarters, one and a half, two and a quarter, and three hours after they had breakfasted. In order not to surpass the limit of normal assimilation, I ordered a breakfast, consisting of 100 grm. of bread with butter and 200 c.c. of milk, which had also the advantage that psychical abnormal patients ate it with less reluctance than they would show by taking solutions of glycose, &c. There still remain some precautions to be taken, which I shall discuss afterwards.

Researches on Normal Persons.

Previously I examined ten normal men and ten normal women; the results can be seen in the following tables :—

These results tally exactly with the results of other authors, who worked with the method of Bang. According to Bang, the normal percentage of blood-sugar varies between 0·70 and 1·10 per mille. In his opinion, the sex does not make any difference worth mentioning, and this was the case with my results.

Elzas (1916), working by the same method, found the amount to vary from 0·80 per mille to 1·15 per mille (average 1 per mille). Ryser (quoted from von Noorden), 0·63 to 1·05 per mille (average 0·86 per mille). Von Noorden (1917), 0·70 to 1 per mille, usually 0·80 to 0·90 per mille.

Normal Men.

	Name	Age	Before breakfast	After breakfast			
			Per mille	¾ hour Per mille	1½ hours Per mille	2¼ hours Per mille	3 hours Per mille
1	d. B.	23	1·00	1·27	1·22	1·15	1·12
2	M.	38	1·05	1·27	1·19	1·21	1·05
3	H.	21	0·96	1·13	1·23	0·93	0·91
4	J.	23	1·07	0·93	0·96	1·03	0·98
5	v. d. H.	20	0·91	1·14	1·04	1·02	1·00
6	S.	20	1·09	1·05	1·09	1·08	1·10
7	L.	22	0·98	1·11	1·07	1·04	1·05
8	P. H.	26	1·03	1·13	1·07	1·16	1·20
9	V.	35	0·95	1·24	1·21	0·90	0·99
10	W.	54	0·87	1·07	1·13	1·01	0·86
	Average		0·99	1·13	1·12	1·05	1·03

Normal Women.

	Name	Age	Before breakfast	¾ hour	1½ hours	2¼ hours	3 hours
1	W.	25	0·94	0·99	0·97	0·90	0·93
2	S.	40	0·95	1·17	1·16	0·92	0·93
3	G.	22	0·95	0·96	0·98	1·03	0·87
4	S.	37	1·09	1·27	1·25	1·23	1·13
5	W.	20	1·04	1·14	1·12	1·07	1·09
6	H.	21	0·86	1·18	1·18	0·83	0·88
7	J. R.	22	1·0	1·13	0·94	0·96	0·91
8	v. L.	49	0·78	1·05	0·93	0·98	0·81
9	M.	22	1·0	1·28	1·11	1·08	1·19
10	de V.	14	1·06	1·24	1·30	1·25	1·28
	Average		0·97	1·15	1·19	1·02	1·00
	Average of both sexes		0·98	1·14	1·16	1·04	1·02

All these numbers refer to the amount of blood-sugar before breakfast.

After breakfast, Bang, and also von Noorden, found a small increase of the amount of blood-sugar. Elzas gave 150 grm. of bread and one cup of tea without milk or sugar, and found an increase respectively from 1·06 per mille before breakfast to 1·36 per mille one hour after breakfast; 1·08 to 1·30; 1·10 to 1·27; 0·80 to 1·28; 0·91 to 1·03; 1·07 to 1·38; 1·14 to 1·45; 1·15 to 1·42; 0·98 to 1·35; 1·09 to 1·38 per mille.

This increase is rather high; the amounts found by Elzas before breakfast were also higher than those of most other authors, as well as mine; moreover he gave more starch than I did.

There are some precautions which must not be neglected in these experiments.

(1) Of course the persons examined must not have any bodily diseases, which are apt to influence the amount of blood-sugar, such as cerebral lesions, infectious diseases, nephritis, great loss of blood diseases of the liver, &c.

(2) Also the temperature of the environment must be constant. Warm-blooded animals show an increase of the sugar percentage in the, cold (Bang); on the contrary, de Langen (1916, 1918) has observed a considerable increase of blood-sugar in animals and man in the tropics. Senator (1909) observed a constant increase of blood-sugar in rabbits, on which the "piqûre" of Sachs-Aronsohn was performed (puncture in the corpus striatum, where the temperature centre is localized); like de Langen, he could not observe glycosuria. I shall afterwards discuss this incongruity between hyperglycæmia and glycosuria (p. 280). As my examinations took place in the hospital, the temperature of the environment may be assumed to have been constant.

(3) The persons who are to be examined must not work, at least not heavily. For though the opinions of the various authors differ in this respect, it may still have some influence; probably light work gives an increase of blood-sugar, whereas exhaustive labour may reduce it (Bang; Bergsma, 1912). Most of my patients were bedridden, some were walking about without doing work of any importance. The normal persons, whom I examined, did no work at all.

(4) Finally the age is of importance for the blood-sugar. Also with normal persons the amount of sugar increases in advanced age (von Noorden, 1917). Laudenheimer (1898) found in psychoses above the age of 60 a ten times greater frequency of glycosuria than below the age of 60; Ehrenberg (1909) had the same results. As will appear from my tables, this factor has not influenced my results.

Researches on Psychoses.

I feel obliged to give a short clinical history of each patient I examined, as with our present knowledge of psychiatry I think it is not justifiable to mention the diagnosis only. Not only is the nomenclature widely different in the various countries and in the various publications even of fellow countrymen, but also the opinions about psychical diseases are still totally unsettled; quite different diseases have been described (and find their way into literature), e.g., by the name of psychasthenia, of dementia præcox, and also of melancholia. So, if in psychoses facts are stated, they must remain connected with the complex of symptoms in which they were observed; this is the only way finally to collect facts which belong together.

In my opinion, an exception is formed by epilepsy and dementia paralytica. In order to be short, I shall not give a clinical history in these cases. Of the sufferers from epileptic seizures, I have chosen those only who did not show any bodily abnormalities and who had already suffered for several years from well-observed general epileptic attacks, some of them being decidedly demented; they all represented types of the so-called genuine epilepsy.

For examples of dementia paralytica, I have also chosen undeniable types of this disease, all showing, besides the characteristic dementia, several of the well-known bodily changes (alterations of pupils, and tendon-reflexes, tremor, apoplectic and epileptic attacks, positive reaction of Wassermann in blood and cerebro-spinal fluid).

Having taken these precautions, I think it admissible to omit the history and to give only the results. I have principally examined cases of melancholia and of confusional insanity, and some cases of mania, whereas I have taken the other psychoses, dementia præcox, paralytic dementia and epilepsy, as a means of control only.

Blood-sugar in Dementia Præcox.

I examined ten sufferers from dementia præcox. It is a well-known fact that the opinions of the various authors differ widely with regard to this chapter of psychiatry. Even in the successive editions of Kraepelin's text-books different conceptions of dementia præcox are found, while Bleuler's (1911) definition of dementia præcox is still more comprehensive.

In my opinion, entirely different groups of psychoses are combined in this way. I have tried to avoid possible mistakes in classification by examining only types of the so-called hebephrenia, who all showed, as may be seen in the history, the well-known clinical symptoms of dementia præcox: the autism and loss of real interest in matters of daily life; the high degree of suggestibility on the one side and of negativism on the other, with all the abnormal movements and positions dependent on it; the incomprehensible associations in speaking and acting.

A second difficulty is caused by the fact that, in my opinion, it is quite impossible to make a diagnosis with absolute certainty from the complex of symptoms only, even if these symptoms are otherwise typical for dementia præcox.

In order to be able to pronounce a decisive opinion on diagnosis and prognosis, or to register symptoms as belonging to dementia præcox, it is absolutely necessary that the disease be observed for a long time. For that reason I chose only patients who had already suffered from the typical symptoms for several years. No. 6 had been ill for the last half-year only, but then he had the typical symptoms and showed no signs of improvement at his departure.

No. 1.—F. P., female, aged 24. Two relatives at the second remove insane; further family history negative. Psychical alteration for three years, taciturn, doing no work, always staring; hebephrenic laugh; often cutting a queer face, not caring for her relations. In hospital the same symptoms. No bodily changes.

Blood-sugar.

August 20, 1918: Seemed anxious on admission. Pulse, 142; four hours after breakfast, 1·59 per mille.

August 21: Before breakfast much calmer. Pulse, 92; blood-sugar, 1·33 per mille.

August 22: Blood-sugar before breakfast, 1·20 per mille.

August 23: Blood-sugar before breakfast, 1·20 per mille.

August 24: Blood-sugar before breakfast, 1·07 per mille.

August 26: Blood-sugar before breakfast, 1·01 per mille.

October 9: Quite calm. Before breakfast, 0·89 per mille; three-quarters of an hour after breakfast, 1·07 per mille; one and a half hours after breakfast, 1 per mille; two and a quarter hours after breakfast, 0·98 per mille; three hours after breakfast, 0·91 per mille.

No. 2.—J. D., male, aged 38. Mother melancholic, further family history negative. Abnormal for seven years. Began with excitement, anxiety, aggressiveness spoke much about the Bible and Socialism, afterwards taciturn, laughing suddenly, staring with vacant eyes. Was in asylum for one and a half years. Did not recover.

In hospital reticent, many stereotyped actions, catalepsy, automatic movements. Slight dementia. No bodily changes.

Blood-sugar.

October 7, 1918: Quite calm. Before breakfast, 0·88 per mille; three-quarters of an hour after breakfast, 1·07 per mille; one and a half hours after breakfast, 1·14 per mille; two and a quarter hours after breakfast, 1·07 per mille; three hours after breakfast, 1·13 per mille.

No. 3.—H. P., male, aged 42. Father alcoholic, further family history negative. Patient has been abnormal from his 18th year, when he was in prison for some months.

Taciturn, said strange things, was always laughed at, earned little, occasionally stayed in bed for some days, often talked nonsense; several stereotyped movements.

In hospital reticent, apathetic, stereotyped movements, catalepsy. No bodily changes.

Blood-sugar.

February 15, 1919: Quite calm. Before breakfast, 0·77 per mille; three-quarters of an hour after breakfast, 1·22 per mille; one and a half hours after breakfast, 1·10 per mille; two and a quarter hours after breakfast, 0·97 per mille.

No. 4.—J. D., male, aged 21. One brother suffering from dementia præcox for several years.

Became more and more taciturn from his 10th year, stayed in bed, was quite indifferent to reproof, showing stereotyped actions, often staring.

In hospital behaving like a typical case of hebephrenia; reticent, stereotyped attitudes, hebephrenic laugh, &c. No bodily changes.

Blood-sugar.

February 15, 1919: Quite calm. Before breakfast, 0·81 per mille; three-quarters of an hour after breakfast, 1·22 per mille; one and a half hours after breakfast, 1·01 per mille; two and a quarter hours after breakfast, 0·92 per mille.

No. 5.—L. C. K., male, aged 28. Family history negative. Always a backward child (intellectually). Three years ago he became abnormal rather suddenly. Hallucinations, anxiety, persecutory delusions. Was treated in asylum and diagnosed dementia præcox, with symptoms of negativism, catalepsy, hallucinations and delusions. Never normal again, behaving strangely, childishly; stereotyped movements. Doing no regular work.

In hospital same symptoms. No bodily changes.

Blood-sugar.

November 16, 1918: Quite calm. Before breakfast, 0·99 per mille; three-quarters of an hour after breakfast, 1·13 per mille; one and a half hours after breakfast, 1·13 per mille; two and a quarter hours after breakfast, 1·02 per mille.

No. 6.—J. J. B., male, aged 22. Family history negative. Psychical alteration for about eight months. Taciturn, no interest in his surroundings, stereotypic, cataleptic, probably hallucinations, always staring with vacant eyes. Sometimes negativism. No bodily changes.

Blood-sugar.

September 24, 1918: Quite calm. Before breakfast, 0·99 per mille; three-quarters of an hour after breakfast, 1·17 per mille; one and a half hours after breakfast, 1·06 per mille; two and a quarter hours after breakfast, 0·94 per mille; three hours after breakfast, 1·16 per mille.

No. 7.—J. H., female, aged 21. Family history negative. Abnormal for three years. Behaving strangely, stereotypically, without sense, laughing without reason, could not do the work she used to do.

In hospital the above-mentioned symptoms, typical schizophrenia. No bodily changes.

Blood-sugar.

October 8, 1918: Quite calm. Before breakfast, 0.76 per mille; three-quarters of an hour after breakfast, 1·16 per mille; one and a half hours after breakfast, 0·99 per mille; two and a quarter hours after breakfast, 0·85 per mille; three hours after breakfast, 0·76 per mille.

No. 8.—R. B., female, aged 52. Family history negative. Became abnormal on her twentieth year (after unhappy love affair ?). Since then never normal; occasionally excited, with hallucinations and delusions, always acting strangely, abruptly, living in complete bewilderment; had a collection of twenty-five pairs of shoes; on her first admission she wore seventeen skirts, eight under-vests, six chemises, three pairs of drawers, and three pairs of stockings; always talking, but complete nonsense only. The same psychical state on the second admission to hospital. Intellectual activity bad. No bodily changes.

Blood-sugar.

December 23, 1918: Continuously talking nonsense, no real excitement or emotion. Before breakfast, 1·13 per mille; three-quarters of an hour after breakfast, 1·18 per mille; one and a half hours after breakfast, 1·23 per mille; two and a quarter hours after breakfast, 1·07 per mille.

No. 9.—A. A. H., female, aged 28. Family history: both parents alcoholic. Psychical alteration since April, 1916. Began with anxiety, paranoid delusions, hallucinations; afterwards calmer, but behaving strangely, impulsively. After her first stay in hospital she neglected her household, often suffered from mutism; acted impulsively, quite indifferent to the death of her husband, became very erotic.

On second admission into hospital, all symptoms of dementia præcox. No bodily changes.

Blood-sugar.

September 24, 1918: Fairly calm, erotic. Before breakfast, 0·92 per mille; three-quarters of an hour after breakfast, 1·41 per mille; one and a half hours after breakfast, failure; two and a quarter hours after breakfast, 1·13 per mille; three hours after breakfast, 1·16 per mille.

No. 10.—M. S., female, aged 35. Family history negative. Psychical alteration for ten years. Taciturn, reticent; often staring; wandering away from home; negativistic; paranoid delusions, armed herself with stick; hallucinations. In hospital: reticent, occasionally negativistic, laughing hebephrenically, cataleptic. No bodily changes.

Blood-sugar.

December 18, 1918: Quite calm. Before breakfast, 1·16 per mille: three-quarters of an hour after breakfast, 1·85 per mille; one and a half hours after breakfast, 1·08 per mille; two and a quarter hours after breakfast, 1·21 per mille.

December 21: Calm. Before breakfast, 1·17 per mille; three-quarters of an hour after breakfast, 1·54 per mille; one and a half hours after breakfast, 1·55 per mille; two and a quarter hours after breakfast, 1·22 per mille.

February 17, 1919: Calm. Before breakfast, 0·94 per mille; three-quarters of an hour after breakfast, 1·63 per mille; one and a half hours after breakfast, 1·15 per mille; two and a quarter hours after breakfast, 1·11 per mille.

If, in the case of No. 1, we take the observation at the time when she had become accustomed to the hospital, and if we take in the case of No. 10 the average of the three examinations, we may put down as *the average in these ten cases of dementia præcox* respectively:—

Before breakfast	0·93 per mille.
Three-quarters of an hour after breakfast	1·23 ,,
One and a half hours after breakfast	1·10 ,,
Two and a quarter hours after breakfast	1·10 ,,

Two only of the ten cases showed a higher amount than 1·30 per mille after breakfast, of whom No. 9 was more or less excited. In the case of G. S. (No. 10) there was no obvious reason for the invariably increased amount of blood-sugar. She often blushed deeply, which fact, however, is not seldom seen in dementia præcox. I am inclined to think that emotions are responsible for the increase of blood-sugar in such cases, emotions which the patients are not willing or able to tell.

That emotions play a part, even with persons who afterwards seem to be the most indifferent types of hebephrenia, is shown by the examination of Case No. 1. This girl came into the hospital in a distinctly emotional state of mind, having a pulse of 142 and an amount of blood-sugar (four hours after breakfast) of 1·59 per mille. This percentage showed a decrease on the successive mornings: 1·33 per mille, 1·20 per mille, 1·20 per mille, 1·07 per mille, 1·01 per mille. The patient had become accustomed to hospital life and was quite calm.

The only way to solve the difficult problem of the psychology of dementia præcox is by noting the involuntary bodily changes which accompany psychical processes; for all reactions, noted during psychological examination of the patient, are only fit to demonstrate the abnormalities of the sufferer, not to get to the bottom of things. The examination of blood-sugar may also help us in this way. But, in my opinion, many examinations of dementia præcox patients are necessary in many different conditions of mood, and also a careful comparison with other bodily reactions, before we are in a position to draw any conclusions.

These results correspond to those of Schultze and Knauer (1909), who found absence of glycosuria in the apathetic form of hebephrenia, whereas glycosuria was often demonstrated in cases of catatonic excitement, especially after anxious hallucinations. Travaglino (1911) described a catatonic patient suffering from glycosuria, which came and went parallel with depression, anxiety and hallucinations; he did not observe glycosuria in the hebephrenic form. Ehrenberg (1909) could not find any alimentary glycosuria in his nine cases of dementia præcox, neither could Graziani (1908) nor Lugiato (1907), whereas Trepsat (1905) observed it in eighteen out of his nineteen cases (five acute cases and fourteen chronic ones) after a dose of 150 gr. of glycose. [See, for literature, Allers (1913.)]

Heidema (1918) is the only one who examined the percentage of blood-sugar before breakfast in dementia præcox more carefully.

In ten of his thirteen cases he found a more or less marked hyperglycæmia, but nearly all these thirteen patients had only suffered from the illness for a few months or half a year, and judging from the author's notes the diagnosis was often not certain.

The possibility that some of Heidema's cases were not really sufferers from dementia præcox[1] and the fact that, if the diagnosis was correct, they certainly were examined in a more acute stage of their illness than my patients, may explain the difference between Heidema's results and my own sufficiently.

Blood-sugar in Dementia Paralytica.

According to the text-books of Kraepelin (1910) and of Church and Peterson (1914), intermittent glycosuria is a symptom which is occasionally met with in paralytic dementia. I do not believe that we can go any farther. Bond (1895) noticed glycosuria in 10 per cent. of the cases, Siegmund (1895) in 27·8 per cent., Strauss (1900) in 9 per cent., and Schultze and Knauer in 67 per cent. Especially the exalted form showed glycosuria, not that of simple dementia. The percentages given by the latter authors are doubtlessly too high.[1] Raimann (1902) did not find glycosuria in paralytic dementia, nor did Heidema (1918). Raimann did not find a marked influence on the assimilation power, though the depressive forms showed a lower number than the rest. Strauss observed alimentary glycosuria in 9 per cent. of the cases, Arndt (1897) in 10 per cent. Finally we have the researches of Heidema, who found a small increase of blood-sugar before breakfast.

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[1] Perhaps some cases belonged to maniacal-depressive insanity or to that large and still undefined group of amentia and amentia-like diseases, in both of which I found a high amount of blood-sugar; Raimann (1902) also found a very low limit of the assimilation power in amentia, even lower than in melancholia.

My own results are the following:—

	Name	Age	Sex	Before breakfast	¾ hour after breakfast	1½ hours after breakfast	2¼ hours after breakfast	3 hours after breakfast	Notes on psychical state
				Per mille	Per mille	Per mille	Per mille	Per mille	
1	B.	58	M.	0·89	1·34	1·30	1·01	1·09	Quite calm in bed; extreme dementia
2	D.	35	M.	1·08	1·35	0·95	0·84	0·86	Merely dementia; quite calm in bed
3	de H.	44	M.	1·07	1·45	1·24	1·41	1·20	Terminal stage; lay sucking in bed
4	H. B.	44	M.	0·95	1·32	1·32	1·41	1·14	In merry mood; delusions of riches; walking about
5	de B.	41	M.	1·02	1·05	1·09	1·01	—	Calm, merely dementia; walking about
6	N.	51	M.	1·01	1·27	1·24	1·05	—	Merely dementia; calm
				1·36	1·36	1·63	1·35	—	During paralytic attacks
7	S.	38	M.	0·87	1·43	1·22	1·03	—	Severe attack of rage directly after breakfast; afterwards calm
				0·83	1·16	1·05	—	—	Walking, calm, merely dementia
8	T.	46	F.	1·09	1·31	1·22	0·84	—	Calm in bed, merely dementia
9	K.	47	F.	1·09	1·55	1·45	1·19	—	Calm in bed, many absurd delusions of power and riches

If we exclude the results of Nos. 6 and 7, obtained in paralytic attacks and in excitement, we get the average:—

1·01 .. 1·31 .. 1·21 .. 1·09 per mille

the average of the *highest amounts* being 1·33 per mille.

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[1] Both Siegmund and Schultze and Knauer examined the urine of every patient several times, but not equally often; moreover, in different diseases, they did not examine the urine an equal number of times; in this way many more sufferers from transitory glycosuria might have been detected in one illness than in another. Schultze and Knauer made another mistake in establishing their percentage by taking the quotient of the number of urine examinations and of the positive results. We not only cannot find how many sufferers from transitory glycosuria there are in the diseases in question in this way, but the percentage is also dependent on the number of examinations, and especially on whether the sufferers from glycosuria were examined more or less often than the non-sufferers.

The amount per mille is doubtless higher than that of normal persons, six of the nine patients having, without excitement or apoplexy, an amount above 1·30 per mille after breakfast.

The results do not disagree with the conclusions arrived at after studying the literature; the amount of blood-sugar usually does not reach the height where glycosuria becomes frequent,[1] but has a tendency to be above the normal.

As paralytic dementia is a disease with typical anatomical changes (to which, I think, the increase of blood-sugar must be attributed), we cannot use it for the question which for the moment arrests our attention.

Blood-sugar in Epilepsy.

I examined eight sufferers from genuine epilepsy. The results are the following:—

	Name	Age	Sex	Before breakfast	¾ hour after breakfast	1½ hours after breakfast	2¼ hours after breakfast	3 hours after breakfast	Notes on psychical state
				Per mille	Per mille	Per mille	Per mille	Per mille	
1	S. D.	59	F.	1·01	1·58	1·31	1·09	1·13	Very irritable, had a severe attack of excitement after breakfast; dementia
2	J. N.	24	M.	0·87	1·23	1·11	0·90	0·82	Quite calm; dementia
3	R. T.	15	M.	0·84	1·08	0·83	0·89	—	Quite calm; dementia
4	W. D.	33	F.	1·00	1·03	1·11	1·16	1·06	Quite calm; slight degree of dementia
5	M. W.	41	F.	1·02	1·36	1·05	0·95	0·97	Quite calm; dementia
6	K.	43	F.	0·90	1·15	1·12	1·15	0·93	Quite calm; no obvious dementia
7	R. I.	14	M.	0·78	1·09	1·00	0·84	0·86	Quite calm; slight degree of dementia
8	K. A.	27	F.	0·88	1·45	1·35	1·01	—	Dementia; very nervous; several little attacks during examination

If we exclude No. 1 (who was examined in an emotional state of mind) and No. 8 (who was very nervous, had several epileptic attacks during examination), we find for the remaining three men and three women rather subnormal amounts, the average of Nos. 2 to 7 being:—

0·90 .. 1·16 .. 1·04 .. 0·98 .. 0·93 per mille

and the average of the *highest amount* being 1·18 per mille.

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[1] Siegmund also describes a case in which sugar appeared in the urine at the beginning of exaltation, and another case where it could be observed directly after a paralytic attack.

Only No. 5 showed an amount per mille above 1·30 (three-quarters of an hour after breakfast) for which no reason could be found. As far as these few observations enable us to draw conclusions we may say that genuine epilepsy itself does not increase the amount of blood-sugar, the momentary state during an attack perhaps excepted, and, of course, if not complicated by an intervening emotion.

This corresponds with the results of former observers as regards glycosuria or alimentary glycosuria.

Bond (1895) did not find glycosuria in epilepsy, neither did Strauss, Schultze and Knauer, van Oordt (1898), or Geelvink (quoted from Strauss).

According to Allers (1912), glycosuria is very rare in epilepsy; only Goolden (quoted from Allers) could observe it during epileptoid attacks, and Florence and Clément (1909) found a decrease of the assimilation power in epilepsy. Siegmund, who seldom found it with epileptic dementia, observed it after several attacks. On the contrary, Strauss and Schultze and Knauer could not even find glycosuria during attacks, and Raimann found in these circumstances a rather high assimilation power. Heidema found in four patients suffering from genuine epilepsy an average of 1·185 per mille, which is rather high in comparison with my results before breakfast. He attributes it to the fact that blood-sugar and glycosuria need not at all be parallel, which is true, of course, as I shall afterwards discuss. However, as we have no examination on blood-sugar in epilepsy, I was obliged to refer to those on spontaneous and on alimentary glycosuria, as being most germane to my researches.

Blood-sugar in Melancholia.

Of all the mental disorders, it is in melancholia that we have the most and best information about carbohydrate metabolism. This illness has been the starting-point for my researches. All nerve specialists know those cases where glycosuria appears at the same time with depression and disappears with psychical improvement; we find it mentioned in the larger text-books (e.g., of Kraepelin, Ziehen, or Aschaffenburg). A detailed discussion of the subject can be found in the papers of Allers (1914), of Schultze and Knauer (1911), of Mita (1912), and of Heidema (1918); so I think it superfluous to give a complete survey of the extensive literature.

Typical cases of glycosuria, dependent on melancholia, have been described, e.g., by Goodhart (1889), Bond (1895), Toy (1895), Schultze and Knauer (1911). The question of glycosuria in melancholia was examined systematically by Schultze and Knauer, that of alimentary glycosuria by Raimann. The first mentioned authors found glycosuria in 67 per cent. of their cases. I refer to p. 227 for my criticism on their method of ascertaining the percentages. According to their researches, however, we may take it for granted that glycosuria is very frequent, even if we do not accept exactly the numbers given by them. For if we consider all those cases as positive in which the authors observed glycosuria at any time, we get a percentage which is much higher than 67 per cent. Especially in anxiety, glycosuria is seldom absent, in accordance with its frequency in emotional states of other diseases. I shall afterwards return to this question.

Raimann found a marked decrease of the assimilation power in melancholia, namely 1·9, the normal average being 3·5.

I have examined the following nineteen cases of melancholia; several of these patients were sufferers from real periodic melancholia; others had their first attack but in all of them there was genuine depression, with concomitant motor inhibition, anxiety, depressive delusions; in none was the depressive mood secondary, dependent on other deeper psychical or bodily causes, nor were there bodily changes or dementia in any of them.

No. 1.—P. de V., male, aged 65. Several members of his family suffered from maniacal-depressive insanity. Patient had had two attacks of melancholia before: depression, motor inhibition, delusion of having sinned; delusions often very absurd. No bodily changes, blood-pressure 130 mm. Hg (Riva-Rocci); examination showed poor intellectual powers, but patient had little school-learning and was very refractory during examination. Heavy drinker in former years.

Blood-sugar.

September 17, 1918: Calm, not agitated. Before breakfast, 1·09 per mille; three-quarters of an hour after breakfast, 1·15 per mille; one and a half hours after breakfast, 1·16 per mille; two and a quarter hours after breakfast, 1·30 per mille; three hours after breakfast, 1·17 per mille.

September 18: Same psychical state. Before breakfast, 1·07 per mille; three-quarters of an hour after breakfast, 1·17 per mille; one and a half hours after breakfast, 1·21 per mille; two and a quarter hours after breakfast, 1·18 per mille; three hours after breakfast, 1·28 per mille.

December 16: Same psychical state. Before breakfast, 1·20 per mille; three-quarters of an hour after breakfast, 1·36 per mille; one and a half hours after breakfast, 1·30 per mille; two and a quarter hours after breakfast, 0·98 per mille.

No. 2.—J. R., male, aged 66. Insane for the first time, became melancholic after the illness and death of his son; depression, delusion of having sinned: high degree of anxiety; speaking and acting slowly; no dementia; no bodily changes.

Blood-sugar.

November 28, 1918: Very anxious. Before breakfast, 1·13 per mille; three-quarters of an hour after breakfast, 1·07 per mille; one and a half hours after breakfast, 1·20 per mille; two and a quarter hours after breakfast, 1·03 per mille.

December 3: Very anxious. Before breakfast, failure; three-quarters of an hour after breakfast, 1·83 per mille; one and a half hours after breakfast, 1·22 per mille; two and a quarter hours after breakfast, 1·02 per mille.

December 14: Very anxious. Before breakfast, 1·37 per mille; three-quarters of an hour after breakfast, 1·61 per mille; one and a half hours after breakfast, 1·17 per mille; two and a quarter hours after breakfast, 1·26 per mille.

No. 3.—H. J. P., female, aged 43. Twin brother committed suicide; father feeble-minded. Patient had already once suffered from melancholia. In 1918 she had several melancholic attacks of short duration; depression; motor inhibition; delusion of poverty; no anxiety; no dementia; no bodily changes.

Blood-sugar.

September 19, 1918: Calm, not anxious. Before breakfast, 1·10 per mille; three-quarters of an hour after breakfast, 1·42 per mille; one and a half hours after breakfast, 1·14 per mille; two and a quarter hours after breakfast, failure; three hours after breakfast, 0·91 per mille.

No. 4.—V. W., female, aged 60. Nervous woman, especially of late years. For the last months: Depression, motor inhibition, agitation, weeping all day; was never melancholic before; no dementia; no bodily changes; blood pressure, 130 mm. Hg (Riva-Rocci).

Blood-sugar.

September 19, 1918: Calm, no anxiety. Before breakfast, 0·93 per mille; three-quarters of an hour after breakfast, 1·41 per mille; one and a half hours after breakfast, failure; two and a quarter hours after breakfast, 1·22 per mille; three hours after breakfast, 0·96 per mille.

No. 5.—G. D. H., female, aged 23. First attack of melancholia; first child born three months before illness broke out. Depression, marked anxiety, delusion of having sinned, motor inhibition, sometimes stupor, attempt at suicide; intellectual examination impossible; no obvious dementia; no symptoms of dementia præcox. Scratching and plucking at everything, afterwards obstinate masturbation. No bodily changes.

Left hospital unrecovered.

Blood-sugar.

September 5, 1918: Anxious. Before breakfast, 1·07 per mille; three-quarters of an hour after breakfast, 1·69 per mille; one and a half hours after breakfast, 1·30 per mille; two and a quarter hours after breakfast, 1·09 per mille; three hours after breakfast, 1 per mille.

September 17: Less anxious, but still depressed. Before breakfast, 1·02 per mille; three-quarters of an hour after breakfast, 1·41 per mille; one and a half hours after breakfast, 1·45 per mille; two and a quarter hours after breakfast, 1·09 per mille; three hours after breakfast, 0·96 per mille.

No. 6.—B. F. de L., female, aged 41. First depressive period, but character was always melancholic. Became depressed after death of her mother. Depression, anxiety, delusion of having maltreated her mother; attempt at suicide; no dementia; no bodily changes.

Blood-sugar.

November 27, 1918. Depression, anxiety (slight degree). Before breakfast, 1·34 per mille: three-quarters of an hour after breakfast, 1·96 per mille; one and a half hours after breakfast, 1·75 per mille; two and a quarter hours after breakfast, 1·33 per mille.

December 7: Same psychical state. Before breakfast, 1·19 per mille; three-quarters of an hour after breakfast, 1·82 per mille; one and a half hours after breakfast, 1·53 per mille; two and a quarter hours after breakfast, 1·08 per mille.

February 4, 1919: Much better, but still very taciturn. Before breakfast, 1·18 per mille; three-quarters of an hour after breakfast, 1·66 per mille; one and a half hours after breakfast, 1·33 per mille; two and a quarter hours after breakfast, 1·39 per mille.

Left hospital not quite recovered.

No. 7.—M. M., female, aged 48. Melancholic depression four years ago. This time melancholia broke out after insignificant operation; depression; delusion of poverty, of having sinned; agitation; no dementia; no bodily changes.

Blood-sugar.

October 9, 1918: Agitated, bewailing her misfortunes. Before breakfast, 1·28 per mille; three-quarters of an hour after breakfast, 1·42 per mille; one and a half hours after breakfast, 1·32 per mille; two and a quarter hours after breakfast, 1·36 per mille; three hours after breakfast, 1·40 per mille.

December 6: Same psychical state. Before breakfast, 1·20 per mille; three-quarters of an hour after breakfast, 1·35 per mille; one and a half hours after breakfast, 1·43 per mille; two and a quarter hours after breakfast, 1·43 per mille.

Left hospital unrecovered.

No. 8.—D. L., male, aged 45. Mother committed suicide; several cases of insanity in family history. Patient suffered from melancholia twice before. This period: Depression, anxiety, depressive delusions, especially of a hypochondriac nature; some psychasthenic symptoms; no dementia; no bodily changes. Left hospital unrecovered; completely recovered in asylum.

Blood-sugar.

November 27, 1918: For psychical symptoms *vide supra*, anxious. Before breakfast, 1·19 per mille; three-quarters of an hour after breakfast, 1·62 per mille; one and a half hours after breakfast, 1·54 per mille; two and a quarter hours after breakfast, 1·44 per mille.

December 6: Same psychical state, anxiety. Before breakfast, 1·11 per mille; three-quarters of an hour after breakfast, 1·90 per mille; one and a half hours after breakfast, 1·39 per mille; two and a quarter hours after breakfast, 1·05 per mille.

No. 9.—A. v. d. W.—female, aged 38. First depressive period; slight depression; motor inhibition; no anxiety; no delusions; no suicidal tendencies; no dementia; no bodily changes; left hospital unrecovered.

Blood-sugar.

November 13, 1918: Calm, slight motor inhibition. Before breakfast, 0·92 per mille; three-quarters of an hour after breakfast, 1·31 per mille; one and a half hours after breakfast, 1·03 per mille; two and a quarter hours after breakfast, 0·91 per mille.

December 5: In the same condition. Before breakfast, 1·02 per mille; three-quarters of an hour after breakfast, 1·18 per mille; one and a half hours after breakfast, 1·34 per mille; two and a quarter hours after breakfast, 0·94 per mille.

No. 10.—A. M. J. M. H., female, aged 41. Melancholic for the first time; depression; depressive delusions; anxiety; no dementia; anæmia (had always looked pale, no change of the blood); no other bodily changes. Left hospital unrecovered.

Blood-sugar.

September 21, 1918: Depression; motor inhibition; no anxiety. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·33 per mille; one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 1·28 per mille; three hours after breakfast, 1·23 per mille.

December 5: Same psychical state. Before breakfast, 1·07 per mille; three-quarters of an hour after breakfast, 1·53 per mille; one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 1·13 per mille.

No. 11.—C. K. B., female, aged 50. Sister of our patient committed suicide. Patient suffered from melancholia once before. This time: depression, agitation, anxiety, depressive delusions of all kinds, two attempts at suicide; no dementia; no bodily changes.

Blood-sugar.

November 13, 1918: Very anxious. Before breakfast, 1·35 per mille; three-quarters of an hour after breakfast, 1·62 per mille; one and a half hours after breakfast, failure; two and a quarter hours after breakfast, 1·24 per mille.

December 5: Same psychical state; anxious. Before breakfast, 1·27 per mille; three-quarters of an hour after breakfast, 1·70 per mille; one and a half hours after breakfast, 1·33 per mille; two and a quarter hours after breakfast, 1·27 per mille.

February 6, 1919: Stuporous; looking very anxious. Before breakfast. 1·20 per mille; three-quarters of an hour after breakfast, 2·04 per mille; one and a half hours after breakfast, 1·65 per mille; two and a quarter hours after breakfast, 1·10 per mille.

March 20: Recovered, about to leave. Before breakfast, 0·79 per mille; three-quarters of an hour after breakfast, 1·18 per mille; one and a half hours after breakfast, 0·98 per mille; two and a quarter hours after breakfast, 1·01 per mille.

No. 12.—J. M., female, aged 34. First attack of melancholia; depression; motor inhibition; no delusions; no anxiety; no dementia; no bodily changes.

Blood-sugar.

September 21, 1918: Slight depression and motor inhibition; no anxiety. Before breakfast, 0·99 per mille; three-quarters of an hour after breakfast, 1·33 per mille; one and a half hours after breakfast, 1·25 per mille; two and a quarter hours after breakfast, 0·98 per mille; three hours after breakfast, 1 per mille.

December 4: Depression; motor inhibition; weeping during examination. Before breakfast, 1·03 per mille; three-quarters of an hour after breakfast, 1·51 per mille; one and a half hours after breakfast, 1·19 per mille; two and a quarter hours after breakfast, 1·03 per mille.

No. 13.—E. de H., male, aged 44. Patient suffered from melancholia twice before. This time he shows: depression; motor inhibition; sometimes marked anxiety. Slight degree of tuberculosis of the lungs; temperature not raised; no anæmia; no cachexia; no other bodily changes. No dementia; melancholic, indecisive character.

Blood-sugar.

October 14, 1918: Depression; motor inhibition; no anxiety. Before breakfast, 1·13 per mille; three-quarters of an hour after breakfast, 1·61 per mille; one and a half hours after breakfast, 1·07 per mille; two and a quarter hours after breakfast, 0.89 per mille; three hours after breakfast, 0·84 per mille.

November 21: Depression; negativism; refusal of food. Before breakfast, 0·96 per mille; three-quarters of an hour after breakfast (only 400 c.cm. of milk), 1·51 per mille; one and a half hours after breakfast, 1·35 per mille; two and a quarter hours after breakfast, 1·06 per mille. Left hospital unrecovered.

No. 14.—F. K., male, aged 68. Had an attack of melancholia fourteen years ago: the outbreak of the present attack was preceded by a short period of excitement. Now: depression; motor inhibition, at the same time anxious, delusion of depressive nature, especially hypochondriacal delusions; no dementia; no bodily changes. Father of patient committed suicide.

Blood-sugar.

November 1, 1918: Psychological state: see above. Before breakfast, 1·13 per mille; three-quarters of an hour after breakfast, 1·57 per mille; one and a half hours after breakfast, 1·52 per mille; two and a quarter hours after breakfast, 1·39 per mille; three hours after breakfast, 1·24 per mille.

November 20: Depression; motor inhibition; not anxious; getting much better. Before breakfast, 1·03 per mille; three-quarters of an hour after breakfast, 1·17 per mille, one and a half hours after breakfast, 1·26 per mille; two and a quarter hours after breakfast, 1·22 per mille. Left hospital nearly recovered.

No. 15.—J. P. L.-S., female, aged 51. Melancholia (for the first time) some weeks after recovery from pneumonia. Depression; depressive delusions; motor inhibition; stuporous on admission into hospital; occasionally anxious; no dementia; no bodily changes.

Blood-sugar.

October 13, 1918: Excited; depressed. Before breakfast: 1·23 per mille; three-quarters of an hour after breakfast, 1·67 per mille; one and a half hours after breakfast, 1·60 per mille; two and a quarter hours after breakfast, 1·57 per mille.

November 21: Depression; motor inhibition; slightly anxious. Before breakfast, 1·45 per mille; three-quarters of an hour after breakfast, 1·82 per mille; one and a half hours after breakfast, 1·78 per mille; two and a quarter hours after breakfast, 1·50 per mille.

December 24: Patient has become maniacal; exaltation; accelerated flow of thoughts; still some depressive delusions. Before breakfast, 1·06 per mille; three-quarters of an hour after breakfast, 1·12 per mille; one and a half hours after breakfast, 1·09 per mille; two and a quarter hours after breakfast, 1·14 per mille.

January 6, 1919: Again depressed; depressive delusions; no motor inhibition. Before breakfast, 1·16 per mille; three-quarters of an hour after breakfast, 1·33 per mille; one and a half hours after breakfast, 1·43 per mille; two and a quarter hours after breakfast, 1·42 per mille.

No. 16.—L. S. B., female, aged 61. Sister committed suicide. Patient had one depressive period previously; this time: depression; anxiety; delusions of depressive nature; attempt at suicide; no dementia; no bodily changes. Left hospital not quite recovered.

Blood-sugar.

September 26, 1918: Anxious. Before breakfast, 0·78 per mille; three-quarters of an hour after breakfast, 1·52 per mille; one and a half hours after breakfast, 1·67 per mille; two and a quarter hours after breakfast, 1·53 per mille; three hours after breakfast, 1·21 per mille.

October 22: Day of departure, very nervous. Before breakfast, 1·28 per mille; three-quarters of an hour after breakfast, 1·73 per mille; one and a half hours after breakfast, 1·58 per mille; two and a quarter hours after breakfast, 1·09 per mille; three hours after breakfast, failure.

No. 17.—M. D. O., female, aged 47. Suffered from depressive insanity once before. This time: depression; very marked anxiety; delusions of depressed nature, especially of having sinned; attempts at suicide; refusal of food; no dementia; no bodily changes. Unrecovered to asylum.

Blood-sugar.

August 16, 1918. Before breakfast, anxious, 0·90 per mille.

August 17: Before breakfast, anxious, 0·88 per mille.

August 19: Before breakfast, anxious, 0·88 per mille.

August 20: Before breakfast, anxious, 1·20 per mille.

August 24: Before breakfast, anxious, 1·24 per mille; three-quarters of an hour after breakfast, 1·77 per mille; one and a half hours after breakfast, 1·33 per mille; two and a quarter hours after breakfast, 1·02 per mille; three hours after breakfast, 1·14 per mille.

August 26: Anxious. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·49 per mille; one and a half hours after breakfast, 1·43 per mille; two and a quarter hours after breakfast, 1·18 per mille.

October 23: Same psychical state; marked anxiety. Before breakfast, 0·93 per mille; three-quarters of an hour after breakfast, 1·46 per mille; one and a half hours after breakfast, 1·75 per mille.

Further examination impossible on account of anxiety. Except for the last time, no muscular exertion. Left hospital unrecovered.

No. 18.—L. M. v. W., female, aged 38. Father died from diabetes. Patient bore emotional character; insane for the first time; depression; marked anxiety; delusions of depressive nature; suicidal tendency; no dementia; no bodily changes. Unrecovered to asylum.

Blood-sugar.

August 16: Before breakfast, anxious, 1·07 per mille.

August 19: Before breakfast, anxious, 1·04 per mille.

August 20: Before breakfast, anxious. 0·87 per mille.

August 21: Before breakfast, anxious; much excited after having seen her child, 1·30 per mille.

August 22: Anxious. Before breakfast, 1·10 per mille; three-quarters of an hour after breakfast, 1·88 per mille; one and a half hours after breakfast, 1·89 per mille. (The patient had, however, taken 200 c.cm. of milk one hour after breakfast); two and a quarter hours after breakfast, 1·63 per mille; three hours after breakfast, 1·21 per mille.

August 23: Anxious. Before breakfast, 1·30 per mille; three-quarters of an hour after breakfast, 1·71 per mille; one and a half hours after breakfast, 1·40 per mille; two and a quarter hours after breakfast, 1·18 per mille; three hours after breakfast, 1·11 per mille.

September 12: Still depressed, but less anxious. Before breakfast, 1·17 per mille; three-quarters of an hour after breakfast, 1·49 per mille; one and a half hours after breakfast, 1·22 per mille; two and a quarter hours after breakfast, 1·16 per mille; three hours after breakfast, 1·13 per mille.

(No muscular exertion during the days of examination.) Left hospital unrecovered.

No. 19.—B. J. D., male, aged 58. Family history negative. Patient had one attack of melancholia before. This time: depression, anxiety, motor inhibition, delusion of having sinned, of poverty, attempt at suicide. No hallucinations, no dementia, no bodily changes.

Blood-sugar.

December 27, 1918: Depression, motor inhibition, no marked anxiety. Before breakfast, 1·24 per mille; three-quarters of an hour after breakfast, 1·56 per mille; one and a half hours after breakfast, 1·51 per mille; two and a quarter hours after breakfast, 1·43 per mille.

January 7, 1919: *status idem.* Before breakfast, 1·02 per mille: three-quarters of an hour after breakfast, 1·67 per mille; one and a half hours after breakfast, 1·44 per mille; two and a quarter hours after breakfast, 1·27 per mille.

February 27: No longer depressed, nearly totally recovered. Before breakfast, 1·0 per mille; three-quarters of an hour after breakfast, 1·29 per mille; one and a half hours after breakfast, 0·99 per mille; two and a quarter hours after breakfast, 0·94 per mille.

No. 20.—H. B. B., female, aged 56. One melancholic attack ten years ago. This time: depression, motor inhibition, anxiety, depressive delusions; no dementia, no bodily changes.

Blood-sugar.

August 15, 1918: Still depressed; no longer anxious; 1·04 per mille.

August 17: Still depressed, no longer anxious; 0·78 per mille.

August 19: Still depressed; no longer anxious; 0·93 per mille.

August 20: Still depressed; no longer anxious; 1·13 per mille.

November 18: Recovering. Before breakfast, 1·01 per mille; three-quarters of an hour after breakfast, 1·19 per mille; one and a half hours after breakfast, 1·26 per mille; two and a quarter hours after breakfast, 0·95 per mille: three hours after breakfast, 0·99 per mille. Left hospital nearly recovered.

No. 21.—D. O. — D., female, aged 34. Suffered from melancholia twice before. This time: depression, motor inhibition, anxiety, no delusions, no dementia; no bodily changes. (Patient was recovering from illness on entering the hospital.)

Blood-sugar.

October 11, 1918: Quite restored to normal psychical state. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·21 per mille; one and a half hours after breakfast, 0·79 per mille; two and a quarter hours after breakfast, 0·78 per mille; three hours after breakfast, 0·80 per mille

No.	Name	Age	Sex	Before breakfast	¾ hour after breakfast	1½ hours after breakfast	2¼ hours after breakfast	3 hours after breakfast	Highest amount
				Per mille	Per mille	Per mille	Per mille	Per mille	Per mille
1	P. de V. ..	65	M.	1·12	1·23	1·22	1·15	1·22	1·36
2	J. R.	66	M.	1·25	1·50	1·20	1·10	—	1·83
3	H. J. P. K. ..	43	F.	1·10	1·42	1·14	—	0·91	1·42
4	v. W.	60	F.	0·93	1·41	—	1·22	0·96	1·41
5	G. D. H. ..	23	F.	1·04	1·55	1·38	1 09	0·98	1·69
6	B. F. de L. ..	41	F.	1·26	1·89	1·64	1·20	—	1 96
7	M. M.	48	F.	1·24	1·39	1·37	1·39	1·43	1·43
8	D. L.	45	M.	1·15	1·76	1·47	1·25	—	1·90
9	A. v. d. W. ..	38	F.	0·97	1·24	1·18	0·92	—	1·34
10	A. M. J. M. H.	41	F.	1·05	1·43	1·36	1·28	1·23	1·53
11	C. K. B. ..	50	F.	1·31	1·66	1·33	1·25	—	1·70
12	J. M.	34	F.	1·01	1·44	1·22	1·00	1·00	1·51
13	E. de H. ..	44	M.	1·04	1·56	1·21	0·97	0·84	1·61
14	F. K.	68	M.	1·13	1·57	1·52	1·39	1·24	1·57
15	J. P. L. S. ..	51	F.	1·33	1·74	1·69	1·53	—	1·82
16	L. S. B. ..	61	F.	1·03	1·62	1·62	1·15	—	1·73
17	M. D. O. ..	47	F.	1·01	1·57	1·50	1·10	1·14	1·77
18	L. M. v. W. ..	38	F.	1·11	1 79	1·64	1·40	1·16	1·88
19	B. J. D. ..	58	M.	1·13	1·61	1·47	1·35	—	1·67
	Average	..	..	1·12	1·55	1·39	1·21	1·10	1·64
Average of patients with marked anxiety (Nos. 2, 5, 8, 11, 16, 17, 18)				1·13	1·63	1·45	1·19	—	1·79
Average of patients without obvious anxiety (Nos. 1, 3, 4, 9, 10, 12, 13)				1·03	1·39	1·22	1·03	—	1·45
Average of patients aged above 50 (Nos. 1, 2, 4, 11, 14, 19)				1·13	1·50	1·39	1·24	—	1·59

As may be seen from the table (p. 238),[1] blood-sugar is much increased in melancholia. Firstly, the amount before breakfast is often too high, the average being 1·12 per mille. This is conformable to the results of Heidema, who found the average of 1·11 per mille, whereas Wigert (1919)[2] found an average of 0·95 per mille in his fourteen cases of melancholia. If we take 1·10 per mille as the limit for normal persons before breakfast, of my nineteen cases, nine had surpassed that number; of Heidema's seventeen cases, ten showed an amount above 1·10, whereas only two of Wigert's cases had surpassed the limit. As the result of these researches, we may say that spontaneous hyperglycæmia is often absent in melancholia, though very likely it is also more often present here than in other psychical diseases. Wigert also examined the alimentary hyperglycæmia, and here his results are in good accordance with mine. He gave 80 grm. glycose and compared his results with those of Jacobsen (1913, No. 97) in normal persons after the same dose of glycose; with normal individuals the amount of 1·40 was surpassed in 56 per cent. of the cases; with the patients of Wigert, this was the case with 91 per cent. Glycosuria (after taking 80 grm. glycose) was found absent by Jacobson in 65 per cent.; with melancholia according to Wigert only in 17 per cent.

For further details I refer to the paper of Wigert: these numbers may suffice to show the perfect harmony between the results of Wigert and my own; whereas the amount before breakfast is very inconstantly increased, there is in melancholia a fairly constant alimentary hyperglycæmia, as well after starch as after glycose.

To what factor must this increased blood-sugar be attributed? That this depends on the illness itself is clear, not only from the long-known fact that glycosuria appears and disappears with the depression, but also from my researches, as I was able to examine the Cases 11, 14, 15, and 19 while they were recovering; in these cases the amount of blood-sugar had decreased on recovery. To many of Wigert's and my own patients, opium was given. But opium has, according to af Klercker (1914-15), a decreasing influence on the amount of blood-sugar, which he ascribes to its inhibitory power on the peristalsis of the stomach. At any rate, my results cannot be increased by gastro-intestinal movement; the weak intestinal peristalsis in melancholia (even without opium) can only have a decreasing influence on the blood-sugar, as the sugar of the food is more slowly absorbed. Chloral hydrate, which, according to Jacobsen (1913 [96]), may cause an increase of blood-sugar, was only occasionally given to my patients; moreover, it was never prescribed on the days of examination.

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[1] In this table the blood-sugar amounts noted for each patient represent the averages of the percentages found by the several examinations on the height of the disease.

[2] I have taken the average of his several examinations of each patient, and again the average of these numbers. They have great value on account of the large number of examinations.

That the age, which might be of influence according to Laudenheimer and Ehrenberg (see p. 220), does not make any difference is shown by the percentage of the several patients aged 50 or above (see table, p. 238). Wigert mentions the bodily weight as a factor which might influence the amount of blood-sugar. The increase of blood-sugar would be inversely proportional to the weight. I do not know whether any experiments have been made which would justify this supposition, but in this form it seems to be highly improbable. According to Scott (1914), the weight is probably without special influence upon the concentration of sugar in the blood; it decreases, however, as the amount of blood drawn per kilo of body weight of the animal increases. Sufficient data have not been obtained to establish the mathematical expression for this relation ([160] p. 306). Wigert suggests still another possibility. According to Bang, sugar given to animals after hunger leads to a higher amount than when they are well fed; now melancholics are often under-fed, and this fact might partly explain the high blood-sugar after taking glycose. Of course I do not know the weight of my patients before admission, but I am sure that most of them are not under-fed after a long stay in hospital, as great care is taken to feed them regularly. This condition cannot be the reason of the increase of blood-sugar in my cases. Moreover, it cannot explain the several cases of high amounts before breakfast.

The theory of Raimann will be discussed in the following chapter on mania.

In my opinion only one satisfactory answer to the question can be given; *it is the emotional state that is responsible for the high amount of blood-sugar*. First of all, this supposition makes us understand the bad influence of emotions on saccharine diabetes; it is in agreement with the occurrence of emotional glycosuria in animals and man and to the fact that also of the other psychoses it is the emotional cases that show glycosuria, as was found by Mita for hysteria and neurasthenia; by von Jaksch (1895), Arndt (1897), and Horn (1915), for traumatic neuroses; by Goodhart for neurasthenia; by Travaglino (1911) for catatonia and dementia senilis; by Strauss (1900) for imbecility; by Schultze and Knauer for dementia præcox, for imbecility and for dementia paralytica. [See also Case 7 (p. 227), of my patients suffering from dementia paralytica, and of epilepsy, Case 1 (p. 228)].

Blood-sugar in Neurasthenia and Psychasthenia.

It is here the place to mention four cases of true neurasthenia and psychasthenia without any bodily abnormalities, which I examined on several occasions.

No. 1.—K., male, aged 47, neurasthenic nervous person, but calm during examination: 1·04 per mille, 1·35 per mille, 1·00 per mille, 0·91 per mille, 0·90 per mille.[1]

No. 2.—H., male, aged 44, had suffered from psychasthenia for several years; quite calm during first examination: 1·09 per mille, 1·08 per mille, 1·09 per mille, 0·95 per mille, 1·02 per mille. Anxious and excited during second examination because of imperative ideas (phobias): 1·02 per mille, 1·50 per mille, 1·13 per mille, 0·92 per mille, 0·87 per mille.

No. 3.—D., male, aged 43, typical neurasthenic; made a very emotional impression that morning four hours before breakfast: 1·47 per mille.

No. 4.—E., male, aged 36, psychasthenia, agitation, imperative ideas, pulse 132. Two hours after breakfast (two rusks and one cup of milk): 1·87 per mille.

These results correspond quite well with those of the above-mentioned writers and show plainly the undeniable fact that emotions cause hyperglycæmia in man. I will add to these cases the account of six cases of *confusional insanity.* At first I intended to give a full survey of the emotional state and its reactions in this illness, as I have examined twenty cases. But afterwards the matter seemed to me to be too intricate to insert its detailed discussion into this paper; for it is still an open question whether amentia without palpable cause really exists (*vide* e.g., Stransky, 1904-06; Kraepelin, 1910), or whether confusional insanity after psychical or bodily traumata, after infectious diseases, or after delivery, &c., must be grouped together or ought to remain separated. Therefore I only took some representatives of the various groups merely to demonstrate the influence of emotion on the blood-sugar, also in this form of insanity.[1] For convenience' sake I have called them all amentia.

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[1] The numbers indicate the blood-sugar before breakfast, three-quarters of an hour after breakfast, &c.

Blood-sugar in Amentia.

No. 1.—H. T. G., female, aged 41. Husband died on November 16, 1918; patient became depressed in the last days of her husband's life; after his death, incoherence, excitement, hallucinations, laughing and singing alternately. No bodily changes, no fever.

Blood-sugar.

December 2, 1918: Exaltation, talking incessantly. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·13 per mille; one and a half hours after breakfast, 1·51 per mille; two and a quarter hours after breakfast, 1·35 per mille.

December 10: Same psychical state. Talking incessantly. Before breakfast, 1·30 per mille; three-quarters of an hour after breakfast, 1·24 per mille; one and a half hours after breakfast, 1·40 per mille; two and a quarter hours after breakfast, 1·31 per mille.

January 29, 1919: Much calmer. Before breakfast, 0·96 per mille; three-quarters of an hour after breakfast, 1·33 per mille; one and a half hours after breakfast, 1·34 per mille; two and a quarter hours after breakfast, 0·91 per mille.

No. 2.—R. v. D., female, aged 48, Jewess. Became incoherent after operation; then followed erysipelas; she recovered from both, but the insanity became worse; incoherence, illusions and hallucinations, disorientation, motor excitement: very marked exaltation; sometimes anxious and weeping: at other times singing; temperature a little raised (cystitis). No other bodily changes. Temperature in the mornings always normal, in the evenings sometimes normal, often a little raised.

Blood-sugar.

August 21, 1918. Before breakfast, 1·07 per mille.

August 22: Before breakfast, 1·66 per mille.

August 23: Before breakfast, 1·28 per mille.

August 24: Before breakfast, 1·11 per mille.

August 26: Before breakfast, 1·20 per mille; temperature normal in the morning, sub-febrile in the evening; patient alternately calm and excited; orientation much better, sometimes still hallucinations.

August 28: Before breakfast, 1·08 per mille; fifty minutes after breakfast, 1·44 per mille; one hour fifty minutes after breakfast, 1·71 per mille; two hours forty minutes after breakfast, 1·26 per mille.

August 29: Before breakfast, 1·20 per mille; three-quarters of an hour after breakfast, 1·48 per mille; one and a half hours after breakfast, 1·77 per mille; two and a quarter hours after breakfast, 1·44 per mille; three hours after breakfast, 1·26 per mille.

September 26: Recovered from illness, psychical state quite normal again. Before breakfast, 0·81 per mille; three-quarters of an hour after breakfast, 1·08 per mille; one and a half hours after breakfast, 1·04 per mille; two and a quarter hours after breakfast, 1·08 per mille; three hours after breakfast, 0·87 per mille.

No. 3.—J. P. G., female, aged 42. Family history negative; ten weeks before admission, eighth delivery without complications, seven weeks afterwards patient fell ill (never insane before); began with delusions and anxiety, afterwards exaltation; total incoherence; anxiety; complete disorientation. No bodily changes.

Blood-sugar.

November 1, 1918: Incoherent, sometimes anxious. Before breakfast, 1·39 per mille; three-quarters of an hour after breakfast, 1·64 per mille; one and a half hours after breakfast, 1·71 per mille; two and a quarter hours after breakfast, 1·69 per mille.

November 15: Quite recovered, normal psychical state. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·07 per mille; one and a half hours after breakfast, 1·22 per mille; two hours and a quarter hours after breakfast, 1·18 per mille.

No. 4.—A. V. E., female, aged 28 (puerperal insanity). No insanity before or during pregnancy; difficult labour; four days after delivery she became depressed; afterwards incoherent, very excited; in hospital: stupor, incoherence, sometimes exaltation.

Blood-sugar.

August 26: Calm, but incoherent: temperature normal. Before breakfast, 1·24 per mille.

August 28: The same. Before breakfast, 1·04 per mille.

August 29: The same. Before breakfast, 2·09 per mille (very angry with one of the nurses); three-quarters of an hour after breakfast, 1.52 per mille; one and a half hours after breakfast, 1·70 per mille; two and a quarter hours before breakfast, 1·49 per mille; three hours after breakfast, 1·39 per mille.

August 30: Before breakfast, 1·23 per mille; three-quarters of an hour after breakfast, 1·54 per mille; one and a half hours after breakfast, 1·54 per mille; two and a quarter hours after breakfast, 1·75 per mille; three hours after breakfast, 1·55 per mille.

October 7: Patient has greatly changed; no stupor; no exaltation or anxiety; but garrulity; childishness; tendency to make stupid jokes.

Before breakfast, 0·90 per mille; three-quarters of an hour after breakfast, 1·45 per mille; one and a half hour after breakfast, 1·46 per mille; two and a quarter hours after breakfast, 1·15 per mille; three hours after breakfast, 0·98 per mille.

November 15, 1918: Much better, is going to leave hospital: not quite recovered; still somewhat childish. Before breakfast, 0·84 per mille; three-quarters of an hour after breakfast, 1·33 per mille; one and a half hour, 1·38 per mille; two and a quarter hours after breakfast, 1·22 per mille.

No. 5.—H., female, aged 37. Family history negative; patient suffered once before from an attack of amentia after pneumonia. This time Spanish influenza; after fever had left, incoherence, disorientation, at first more stuporous, afterwards excited, anxious, totally incoherent. In hospital: incoherence; exaltation; extreme emotional state; hallucinations; anxiety. No bodily changes, no fever.

Blood-sugar.

November 16, 1918: Incoherent; very emotional; anxious; dilated pupils; high colour; rapid pulse; no motor excitement. Before breakfast, 1·19 per mille; three-quarters of an hour after breakfast, 2·04 per mille; one and a half hours after breakfast, 1·82 per mille: two and a quarter hours after breakfast, 1·12 per mille.

December 21: Much calmer; much less emotional; no colour; still some incoherence. Before breakfast, 1·28 per mille; three-quarters of an hour after breakfast, 1·46 per mille; one and a half hours after breakfast, 1·35 per mille; two and a quarter hours after breakfast, 1·12 per mille. Left hospital nearly recovered.

No. 6.—S., female, aged 56.—Family history negative. Patient never had any bodily or mental diseases. Caught Spanish influenza at the end of October. Became insane directly after influenza; confusion; incoherence; hallucinations; motor excitement; spitting; shouting; very restive; refuses to speak and to eat. No longer bodily changes. Temperature normal again.

Blood-sugar.

November 28, 1918: For psychical symptoms, see above. Before breakfast, 0·98 per mille; three-quarters of an hour after breakfast, 1·54 per mille, one and a half hours after breakfast, 1·76 per mille; two and a quarter hours after breakfast, 1·40 per mille.

December 14: Convalescent, much calmer. Before breakfast, 1·24 per mille; three-quarters of an hour after breakfast, 1·24 per mille; one and a half hours after breakfast, 1·34 per mille; two and a quarter hours after breakfast, 1·41 per mille.

Left hospital nearly recovered.

As may be seen from these reports, the blood-sugar is very much increased when the patients are in a highly emotional state, whereas it decreases on recovery. In the first four cases this increase cannot be ascribed to any bodily changes, as the reason of the illness had ceased to exist months ago, and no bodily abnormalities had remained. In the cases of amentia after Spanish influenza, one might think of toxins, which still were circulating and disturbing the metabolism; this, however, is very improbable, as other mental disorders after influenza, without excitement, in which according to that supposition the same toxins must be present, do not show that high increase of blood-sugar (cf. Case 2, T. B., on p. 249).

The influence of anxiety is very striking, especially with melancholia, as may be seen from the table (p. 238); the amount of blood-sugar before breakfast in anxious patients is the same as the general average, but the increase after breakfast is greater, the curve being steeper. If we compare these amounts with those of patients without obvious anxiety, the difference is still clearer.[1] Of course the greatest difference exists between the averages of the highest amounts of anxious and not anxious patients. Therefore I take it for granted that anxiety plays an important part in melancholic hyperglycæmia; the only question which remains to be answered is whether blood-sugar is also increased in simple depression, without marked anxiety. First I may draw attention to the fact that anxiety in any degree is very seldom absent in true melancholia; one of the characteristics of pathological depression is that it nearly always shows a tinge of anxiety or agitation; I hardly remember a case where that symptom was wanting in the history and present state, if we look for it in all its variations, from pathognomonic restlessness and agitation to the highest precordial distress. How often we may find even in stupor, when all emotion seems to be extinguished, that anxiety was merely slumbering. That there may be still another reason why depression itself is associated with an increase of blood-sugar I hope to make clear in the second chapter.[2]

Blood-sugar in Mania.

We have but little information about the amount of blood-sugar in mania, as the illness is doubtless rare. Schultze and Knauer examined six cases, Raimann four, and Heidema three cases. My material, as regards true mania, is also rather poor, but the Spanish influenza has furnished the hospital with so many psychoses, of which several showed typical maniacal symptoms, that a discussion may be justified. Schultze and Knauer found no glycosuria in their cases except occasionally, when the patients were recalcitrant or excited. In accordance Raimann found a high assimilation-power in mania. Heidema, however, found a rather high amount in his three cases: 1·13, 1·28, and 1·60 per mille before breakfast.

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[1] In the three cases of recovered melancholics I examined, hyperglycæmia appeared to be absent.

[2] After I had finished the table (p. 238), I examined eight more patients suffering from melancholia. The results formed a complete confirmation of those laid down in the table; all these patients, without any exception, showed a marked hyperglycæmia.

Now in mania it is difficult to answer our question; in the first place the motor excitement, if extreme, may cause a decrease of blood-sugar, whereas it may cause an increase if the movements are moderate, and can be compared with normal bodily labour (cf. p. 220). In the second place, a sufferer from mania may be examined in very different moods, especially different in regard to the question we are discussing. Whereas the melancholiac is full of his grief, and only more or less agitated, but always in an emotional state, the maniacal patient is optimistic, cheerful, talkative, then again highly excited, nearly incoherent, or in a state of severe excitement and unwilling towards the examiner. I believe this point to be of grave importance in judging the results of the various authors.[1]

Schultze and Knauer found glycosuria with maniacal patients who were excited and resistive; of the four cases of Raimann, three had nearly recovered, of the remaining case we find noted that she was cheerful and erotic. Heidema's three cases were all of the severe type, highly excited, suffering from want of sleep, shouting and destructive.

I shall now discuss my own cases. I must once again draw the attention to Case 15 in my discussion of melancholia, where a melancholic stage suddenly changed into a maniacal one, and then showed a much lower amount of blood-sugar.

No. 1.—A. L. B., female, aged 29. Suffered from mania once before. This time: exaltation; accelerated flow of thoughts; motor excitement; easily distracted; always joking; not markedly emotional; no dementia; no bodily abnormalities; short depressive period before mania.

Blood-sugar.

October 3, 1918: For psychical symptoms *vide supra;* no extreme movements, for patient is tied to the bed. Before breakfast, 0·86 per mille; three-quarters of an hour after breakfast, 1·36 per mille; one and a half hours after breakfast, 1·33 per mille; two and a quarter hours after breakfast, failure; three hours after breakfast, 1·06 per mille.

October 22: Same condition; always joking; no real excitement. Before breakfast, 0·96 per mille; three-quarters of an hour after breakfast, 1·19 per mille; one and a half hours after breakfast, 1·07 per mille; two and a quarter hours after breakfast, 0·77 per mille; three hours after breakfast, 0·79 per mille.

Left hospital unrecovered.

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[1] I must, however, call to mind once more the small number of the patients examined, and I do not believe that we are justified in considering our opinion of the carbo-hydrate metabolism in mania a final one.

No. 2.—P. S. H., male, aged 36. Had an attack of mania twice before, recovered completely each time. Now: exaltation; accelerated flow of ideas; no marked motor excitement; easily distracted; delusions of maniacal nature; stereotyped movements; always in high spirits; no bodily changes.

Blood-sugar.

October 23, 1918: Psychical state *vide supra.* Before breakfast, 1·16 per mille; three-quarters of an hour after breakfast, 1·44 per mille; one and a half hours after breakfast, 1·88 per mille; two and a quarter hours after breakfast, 1·26 per mille; three hours after breakfast, 1·24 per mille.

November 5: same psychical state. Before breakfast, failure; three-quarters of an hour after breakfast, 1·32 per mille; one and a half hours after breakfast, 1·51 per mille; two and a quarter hours after breakfast, 1·27 per mille; three hours after breakfast, 1·17 per mille.

February 3, 1919: Much calmer; still in merry mood; joking, but without real excitement. Before breakfast, 1·03 per mille; three-quarters of an hour after breakfast, 1·39 per mille; one and a half hours after breakfast, 1·09 per mille; two and a quarter hours after breakfast, 1·09 per mille.

No. 3.—M. O., male, aged 16. Family history negative; abnormal for a few weeks; talkative; sleepless; wandering about in the night; borrowed 50 guilders and spent it in cafés. In hospital he shows all the symptoms of true mania: exaltation; motor excitement; accelerated flow of thoughts; easily distracted; he is very destructive; singing; shouting; spitting; very resistive; often isolated or in continuous bath; no symptoms at all of dementia præcox; no bodily changes; no dementia.

Blood-sugar.

November 30, 1918: Showing all the symptoms mentioned above. Before breakfast, 1·00 per mille; three-quarters of an hour after breakfast, 1·24 per mille; one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 1·57 per mille.

March 1, 1919: Exaltation; resisting puncture; furious; afterwards calmer. Before breakfast, 0·91 per mille; three-quarters of an hour after breakfast, 1·51 per mille; one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 0·91 per mille.

March 21: Much calmer during last week; optimistic; cheerful; talkative; easily distracted but not excited. Before breakfast, 0·92 per mille; three-quarters of an hour after breakfast, 1·00 per mille; one and a half hours after breakfast, 1·11 per mille; two and a quarter hours after breakfast, 0·91 per mille.

No. 4.—H. B. d. L., male, aged 28. Family history negative. In 1912 short depression, and again during mobilization 1914; wept much at the death of his mother, who died in 1912. In 1917 maniacal stage, followed by a depressive period. In August, 1918, again maniacal period; motor excitement; very talkative; sometimes incoherent; singing; wandering about at night;

giving away his money: irritable; often fighting. In hospital much calmer, talkative; optimistic; singing, not obedient to nurses; meddlesome.

Blood-sugar.

February 1, 1919: Symptoms mentioned above. Before breakfast, 1·09 per mille: three-quarters of an hour after breakfast, 1·01 per mille; one and a half hours after breakfast, 0·98 per mille; two and a quarter hours after breakfast, 0·95 per mille.

February 6: Same psychical state. Before breakfast, 0·83 per mille; three-quarters of an hour after breakfast, 1·20 per mille, one and a half hours after breakfast, 0·94 per mille; two and a quarter hours after breakfast, 1·05 per mille.

No. 5.—A. G., female, aged 28. Family history negative. Became abnormal in the autumn of 1918, excited, talkative, sleepless, alternately depressed and optimistic. After a short period of depression, she became maniacal in the beginning of 1919: exaltation, accelerated flow of thoughts, sometimes incoherence; was irritable, neglected her work, could not remain at home any longer. In hospital, excited, meddlesome, talkative, very irritable, resistive, changing her mood every moment, often weeping, but usually showing the maniacal symptoms. No bodily changes, no symptoms of dementia præcox.

Blood-sugar.

January 17, 1919: Exaltation. Symptoms: see above: Before breakfast, 1·67 per mille; three-quarters of an hour after breakfast, 1·90 per mille; one and a half hours after breakfast, 1·42 per mille; two and a quarter hours after breakfast, 1·11 per mille.

February 5.—Still the same maniacal symptoms, mixed with melancholic ones; weeping this morning, afterwards optimistic, cheerful. Before breakfast, 1·24 per mille, three-quarters of an hour after breakfast, 1·72 per mille; one and a half hours after breakfast, 1·39 per mille; two and a quarter hours after breakfast, 1·03 per mille.

As may be seen from these reports, the results with mania are very variable. In my cases, too, it appears that a simple cheerful optimistic mood usually does not give a high amount of blood-sugar, as may be seen from Case 4; Case 1 was not really emotional. Case 2, on becoming calmer, and being only jocular and optimistic, showed only a slight increase of blood-sugar, while the amount was very high at the climax of the illness. Case 3 was excited and resisting, and excited during the beginning of the second examination; when the patient came to a calmer stage of the illness, and emotion had gone, the blood-sugar was normal again. Case 5 was very emotional; this patient sometimes showed the mixed form of mania depressiva, though as a rule she was maniacal; this state was analogous to that of Case 1 of the amentia group, in which there was also that instability of mood with the strong tendency to optimism and highly increased blood-sugar.

When we now examine the results with *mania or mania-like psychoses after Spanish influenza*, we see this conception affirmed.

No. 1.—G. t. H., female, aged 19. Quite normal till November 13, 1918: influenza; on November 27 she became excited, incoherent. On admittance: exaltation, motor excitement, incoherence, fever.

Blood-sugar.

November 3, 1918: Motor excitement, accelerated flow of thoughts, no fever. Before breakfast, 0·93 per mille; three-quarters of an hour after breakfast, 1·41 per mille; one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 1·04 per mille.

March 20, 1919: Recovered. Before breakfast, 0·74 per mille; three-quarters of an hour after breakfast, 1·08 per mille; one and a half hours after breakfast, 0·80 per mille; two and a quarter hours after breakfast, 0·75 per mille.

No. 2.—T. B., female, aged 28. Father had suffered from melancholia, grandmother died insane, one aunt suffered from epilepsy, another from imbecility. Became incoherent during attack of influenza and pneumonia (before influenza always quite normal). Remained abnormal after recovery from pneumonia. On admission: Talkative, talking nonsense (but knowing this), very erotic, without shame, optimistic, cheerful, no exaltation, no great emotions, no incoherence, no delusions, no hallucinations. Remained in this state for months. Left hospital quite recovered.

Blood-sugar.

December 12, 1918: Symptoms: see above. Before breakfast, 1·06 per mille; three-quarters of an hour after breakfast, 1·20 per mille; one and a half hours after breakfast, 1·24 per mille; two and a quarter hours after breakfast, 1·07 per mille.

December 19: Same psychical state. Before breakfast, 0·84 per mille; three-quarters of an hour after breakfast, 1·22 per mille; one and a half hours after breakfast, 1·29 per mille; two and a quarter hours after breakfast, 1·20 per mille.

January 4, 1919: Same psychical state. Before breakfast, 1·05 per mille; three-quarters of an hour after breakfast, 1 20 per mille; one and a half hours after breakfast, 0·99 per mille; two and a quarter hours after breakfast, 1·16 per mille.

No. 3.—R. B., male, aged 34. Family history negative. Quite normal before influenza. Caught Spanish influenza three weeks before admission. Quite recovered ten days afterwards. Some days after, however, he became excited, talkative, had delusions of expansive character. In hospital: exaltation, accelerated flow of thoughts, motor excitement, easily distracted, no incoherence, no disorientation, no hallucinations, cheerful, optimistic, singing, expansive delusions, no fever, no bodily changes.

Blood-sugar.

November 16, 1918: For symptoms see above. Before breakfast, 1·01 per mille; three-quarters of an hour after breakfast, 1·35 per mille; one and a half hours after breakfast, 1·25 per mille; two and a quarter hours after breakfast, 1·17 per mille

November 30: Same psychical state, not very emotional. Before breakfast, 0·98 per mille; three-quarters of an hour after breakfast, 1·25 per mille; one and a half hours after breakfast, 1·27 per mille; two and a quarter hours after breakfast, 1·29 per mille.

No. 4.—J. v. D., male, aged 42. Family history negative. Quite normal until Spanish influenza in the beginning of November. After recovery he worked again for some days, then became abnormal: talkative, excited, restless, talking nonsense and wandering about; no incoherence. In hospital: exaltation, motor excitement, meddlesome, distractibility, no disorientation, no incoherence, no delusions, cheerful, not irritable, never angry, no fever, no bodily changes.

Blood-sugar.

December 2, 1918: Slight exaltation; no motor excitement. Before breakfast, 1·27 per mille; three-quarters of an hour after breakfast, 1·25 per mille; one and a half hours after breakfast, 1·30 per mille; two and a quarter hours after breakfast, 1·21 per mille.

December 20. Still slight exaltation, optimistic. Before breakfast, 1·25 per mille; three-quarters of an hour after breakfast, 1·60 per mille; one and a half hours after breakfast, 1·10 per mille; two and a quarter hours after breakfast, 1·03 per mille.

No. 5.—A. G., female, aged 22. Family history negative. Emotional character, but no abnormalities before Spanish influenza in the beginning of November. Soon after recovery she became irritable, excited, talkative, sometimes destructive. In hospital: very much excited; sudden changes of mood; as a rule cheerful, making childish jokes motor excitement, easily distracted.

Blood-sugar.

January 17, 1919: Strong exaltation; puncture could only be performed twice. Before breakfast, 1·15 per mille; three-quarters of an hour after breakfast, 1·44 per mille.

February 5: Still excited; same psychical symptoms. Before breakfast, 1·04 per mille; three-quarters of an hour after breakfast, 1·48 per mille;

one and a half hours after breakfast, 1·36 per mille; two and a quarter hours after breakfast, 1·32 per mille.

No. 6.—F. K., female, aged 23. Family history negative. Patient was quite normal until she caught Spanish influenza on November 20, 1918, together with pneumonia. Left bed December 8. On the following day she became excited; talkative. Became more excited every day; talking, singing, incoherent, now and then hallucinations. In hospital: exaltation, accelerated flow of thoughts, no marked motor excitement, optimistic, singing, rhyming, incoherent; no bodily changes, no fever.

Blood-sugar.

December 13, 1918: Marked exaltation, incoherence. Before breakfast, 1·25 per mille; three-quarters of an hour after breakfast, 1·71 per mille; one and a half hours after breakfast, 1·70 per mille; two and a quarter hours after breakfast, 1·33 per mille.

December 19: Same psychical state; maniacal. Before breakfast, 1·14 per mille; three-quarters of an hour after breakfast, 1·62 per mille; one and a half hours after breakfast, 1·32 per mille; two and a quarter hours after breakfast, 1·24 per mille. Left hospital quite recovered. I omitted to examine her blood-sugar then.

The Cases 2, 3 and 4 were not of a highly emotional nature, the emotions being more superficial and transitory, especially in Case 2. The other cases showed more real exaltation. I have, however, no explanation to give for the high amount in the second examination of Case 4.

We may therefore conclude:—

(1) That the amount of blood-sugar in mania and maniacal states often shows a marked increase.

(2) That this increase is highest in real emotional states, such as may occur in mania at its climax, when we almost see the picture of acute delirium and the patient is destructive and very irritable.

(3) That it is smaller, though still present, in the milder form of mania, and

(4) Absent in those hypomaniacal forms, in which the patient is only optimistic, cheerful and inclined to be jocular.

Of course, this conception is quite opposed to that of Raimann. That author, as has been mentioned, found a low assimilation power in melancholia and a high one in mania. He attributes this fact to the inhibition peculiar to melancholia which would also affect the combustion of sugar. Now he examined four cases only of mania, of which at any rate three were convalescent; of the fourth case we do not know whether it was a mild or a severe form. It was therefore impossible for him to judge of the condition in a high emotional state of mania. As for his explanation of the increase in melancholia, this cannot be the correct one. Firstly, it would not explain why the highest increase of blood-sugar was principally found in the patients with marked anxiety and agitation, not only in melancholia, but also in neurasthenia, psychasthenia, amentia, &c.; in these cases the metabolism should rather be accelerated than inhibited. Moreover, according to Bornstein (1908-10) and Grafe (1910), the respiratory quotient is not altered in melancholia, not even in stupor. In this respect there is a marked difference between the (emotional) stupor of melancholia and that of catatonia and paralytic insanity. As for the bodily reactions, melancholia and mania are apparently not so strongly contrasted as might be supposed from their psychical attitudes; this may be easier understood when we bear in mind that these reactions are dependent on, or at least parallel to, emotions, and that both, melancholia and mania, are based on an increased emotional state. That simple depression gives a constant increase of blood-sugar, whereas it is wanting in cheerfulness and optimism, will be explained in the second chapter.

CHAPTER II.—THE THEORIES OF CANNON AND OF GASKELL.

Looking for the deeper reason of this phenomenon, I have argued as follows: Hyperglycæmia in mental diseases is caused by strong emotions, especially those of fear and anger. It is the same emotions which cause glycosuria and hyperglycæmia in animals, and doubtless the phenomenon is the same in man and animals. For if ever a comparison is permitted between human pathology and animal experiments, it is here. Emotions, and especially those of fear and anger, are, phylogenetically speaking, old psychical processes, and are still provided with the old animal reactions; in anger and fear men become animals again. Therefore we must look for the solution of our problem in the animal world, where conditions are much simpler.

Cannon, in his article on emotional glycosuria (1911), was the first to suggest that hyperglycæmia might be useful to the animal, as it provides the muscles with a larger amount of sugar, which is combusted during the actions which may follow or accompany the emotions—i.e., in fight and flight. Then the question arose, whether the mobilization of sugar would be the only consequence of this strong sympathetic impulse in emotion, due to the increase of epinephrin. *A priori* this seemed improbable, as both adrenalin and stimulation of the sympathetic nerve usually have a marked general effect. And, indeed, we find in the excited animal several signs of increased sympathetic stimulation, such as the increase of the heart rate, the widening of the pupils, and the erection of hairs. If Cannon's suggestion were true, it would be probable that not only the increase of blood-sugar, but also the other reactions, dependent on sympathetic stimulation, were useful to the animal in motion. In his splendid monograph on the "Bodily Changes in Pain, Hunger, Fear and Rage" (1918), Cannon has answered this question in the affirmative. However, before giving a short résumé of the principal contents of this publication, I must discuss in short Gaskell's last book, "The Involuntary Nervous System." The conception of the nervous system of this ingenious author seems to me to be of great value for our present problem.

Gaskell points out that the involuntary nervous system is built up on the same principle as the voluntary one; for his arguments I must refer to his publication. According to him, not only the voluntary but also the involuntary nervous system can be divided into a somatic and a splanchnic part. The somatic part is represented by the thoracico-lumbar outflow (sympathetic division); it supplies the heart and the blood-vessels throughout the entire body with motor fibres, and a system of involuntary muscles which possibly arose from a system of dermal muscles, situated exactly under the skin over the whole body ([74], p. 63). It is segmentally built, analogous to the voluntary somatic system which sends motor fibres to the muscles of trunk and extremities. The splanchnic part of the involuntary nervous system, consisting of the bulbar and the sacral outflow,[1] sends motor fibres to the muscles of the alimentary canal and its derivatives; similarly the splanchnic part of the voluntary system innervates only muscles of splanchnic or originally splanchnic function (fifth, seventh, tenth nerves).

According to Gaskell, this division of the nervous system would be more ancient than that into a voluntary and an involuntary part. For the original animal, from which, in his opinion, the vertebrate arose,

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[1] "Autonomes System," of Eppinger and Hesz (1910); in this term the cranial outflow (n. oculomotorius) is included. Gaskell, however, considers the muscular system belonging to this (prosomatic) outflow as a separate group (op. cit., p. 66).

possessed a double segmentation throughout its whole length; a body segmentation and an appendage segmentation. The muscles of these two segmentations, derived originally in the segmented annelids from unstriped muscle, became in part striated and voluntary and partly remained unstriped. The unstriped muscles of the somatic segmentation form the sympathetic or epidermal musculature, and those of the appendage segmentation, the endodermal musculature . . ." (op. cit., p. 64). Sympathetic stimulation in emotions of fear and rage seemed to me much more easily comprehensible in the light of this conception; for it would only be in those conditions which led to the emotions in question, i.e., when the animal had to flee or to fight, that the whole somatic nervous system would come into action, not only the voluntary but also the involuntary system. All the energy of the animal would in moments of danger be withdrawn from the splanchnic system and would be thrown into the somatic system; the striking contrast which the two systems in their functions show would be easily understood. If Cannon's suppositions were right, they would mean a physiological affirmation of Gaskell's anatomical conception.

So two questions remain to be discussed:—

(1) Whether in emotions there really is a general sympathetic stimulation and whether all the resulting reactions are of use to the animal.

(2) Whether in mental disorders the same general sympathetic stimulation is found. For if the increase of blood-sugar has the same cause as it is supposed to have in animals, the parallel must possibly be followed to the end.

Cannon's Theory.

As I have mentioned, Cannon has already answered the first questions in the affirmative. He has ingeniously combined the various researches of himself and his collaborators, and it seems to me that his suggestion in 1911 has now become a solid theory. For the many interesting details, I must refer to his publication. I am, however, obliged to discuss the principal contents shortly, as this is necessary for the right comprehension of the bodily changes in melancholia.

First Cannon points out that emotions such as rage and fear are unfavourable for the normal secretion of the digestive juices and for the contraction of the stomach and intestines, i.e., for those functions that are dependent on stimulation of the splanchnic division of the involuntary nervous system (nervus vagus). On the contrary, these emotions are accompanied by an increased stimulation of the sympathetic division, or, what is the same thing, by increased adrenal secretion. The effect resulting from this stimulation is of signal service to the animal, which must be able to run or fight in the conditions which had led to its emotional state. For Cannon has proved that not only the blood-sugar is increased, by which phenomenon the muscles are enabled to work more and longer, but also that increased adrenalin is an antidote to the effects of fatigue. Moreover, adrenalin has a stimulating effect on the heart and increases the blood-pressure. Now the vessels supplying a muscle dilate when the muscle becomes active; when many muscles are involved in activity, a widely spread dilatation might reduce the blood-pressure to the point at which there would be insufficient circulation in active organs. Therefore the rise of the general arterial pressure is a useful and even necessary compensation. Moreover, adrenalin has no effective influence on the vessels of the lungs and the brain and a vasodilator instead of vaso-constrictor action on the vessels of the heart. Thus the absolutely and immediate essential organs—the heart, the lungs, and the brain as well as its instruments, the skeletal muscles—are in times of excitement abundantly supplied with blood, taken from organs of less importance in critical moments (the intestinal organs) (see Cannon, op. cit., p. 107). The changes in the respiratory function caused by emotions are also favourable to great effort. The deep and rapid respiration which reduces the carbon-dioxide contents of the blood is accompanied by relaxation of the smooth muscles of the bronchioles resulting from increased adrenalin (Trendelenburg, 1912), so that the current of air may pass more freely. Lastly. adrenalin causes a rapid coagulation of the blood which may prevent a possible loss of blood of the fighting animal.

Sympathetic Reactions not discussed by Cannon.

Some effects of increased sympathetic stimulation[1] are not discussed in this monograph.

Erection of hairs.—First there is the erection of hairs; the musculi erectores pilorum are innervated by the sympathetic division, and they certainly come into action during emotions, such as rage and fear.

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[1] In speaking of increased sympathetic stimulation, I also include increased adrenalin secretion, as those two always accompany each other and have the same effect (Elliot).

According to Darwin (1873) the aim is to terrify the adversary, and it is used by some animals in attack (dog), by others in defence (cat); this phenomenon is not only found in mammals, but also in the lower vertebrates (birds and reptiles).

Dilatation of the pupils.—Secondly there is a widening of the pupils in emotion, and this too is a well-known effect of sympathetic stimulation. Cannon only mentions the contracting power of the splanchnic (cranial) division as a proof of the conservative function of this part of the involuntary nervous system (protection of the retina from too intensive light). As widening of the pupil, however, is an active sympathetic phenomenon, according to our scheme we must look for its utility. There are two contrasting opinions about the dilatation of the pupil on sensory and psychical stimuli. Formerly it was the general opinion that these stimuli were conducted by the cervical sympathetic, and accordingly the dilatation of the pupil was called sympathetic reaction. Nowadays most authors seem to be of the opinion of Braunstein (1894) and Bechterew (1895), that the widening of the pupil, dependent on sensory and psychical stimuli, is caused by the inhibitory influence of the cortex cerebri on the tonus of the sphincter iridis (Bumke, 1904—Weiler, 1910). Now we know from the researches of Lewandowsky (1899), that injections of adrenalin cause a dilatation of the pupil. Langley (1901), Gaskell (1916), Elliot (1905) and Eppinger and Hesz (1910) state that both stimulation of the sympathetic and injection of adrenalin cause a dilatation of the pupil. Basing his view on the researches of Waymouth Reid (1895), Gaskell believes in the reciprocal innervation of the m. sphincter and the m. dilatator iridis by the third nerve and the sympathetic, the latter stimulating the m. radiator and inhibiting the sphincter pupillæ. We further know that emotions such as rage and fear cause an increase of adrenalin secretion (Cannon and de la Paz, 1911), and that the same emotions are accompanied by a dilatation of the pupil. In view of these facts, the supposition seems evident that emotion causes dilatation of the pupil by way of increased adrenalin secretion (probably together with a direct stimulation of the cervical sympathetic).

The arguments in favour of the theory of the inhibitory influence of the cortex are chiefly two:—

(1) When the tone of the sphincter iridis has disappeared, sensory and psychical reaction can no longer be obtained. This may be brought about by cutting the third nerve (Braunstein, 1894) or by preventing the light from exerting a stimulating influence on the sphincter tone.

For instance, if we shut the normal eye of a man or animal, whose optic nerve of the other side does not conduct the light, reflex-dilatation is no longer observed on the blind eye (Bechterew, 1883; Braunstein, 1894; Bach, 1908; Weiler, 1910). I want to presuppose first that the example given by Weiler, of tabes, with loss of light-reflex, and at the same time of the sensory-psychical reactions (Erb, Gowers, 1886, and others) is badly chosen, for in tabes the sympathetic system is very probably affected and therefore the loss of psychical reflexes does not prove anything with regard to sympathetic innervation. Gowers (1886) writes in his text-book on nervous diseases (p. 297): "The pupils are often very small (spinal miosis), especially when there is loss of the reflex-dilatation from the skin, a loss which seems to be accompanied by atony of the radiating fibres, supplied by the sympathetic. The pupils are not always small, they may be of medium size or beyond medium size, and then I have usually found that the skin-reflex can be obtained, although the light-reflex cannot." This observation stands rather for than against the sympathetic theory. But even if the conduction of the optic nerve is destroyed by another process, or if the n. oculomotorius is cut, the loss of reflex-dilatation does not go against the sympathetic theory. For in that case there is a hyperfunction of the sympathetic, which makes the pupils dilate, sometimes maximally; psychical and sensory stimuli cannot dilate it any further. Strong sensory stimuli, however, may even then cause a widening of the pupils, of which fact Weiler gives the following explanation: "Sensory and psychical stimuli act exclusively by means of a centre in the cortex cerebri; from this centre inhibitory fibres run to the nucleus of the third nerve. Now sensory stimuli, such as pain, follow the same route, but they act by means of the cervical sympathetic." In view of the strong analogy in the bodily changes, caused by pain and by emotions such as rage and fear, as proved by Cannon, this difference is very improbable. I may here mention the fact that all kinds of asphyxia (Bumke) cause dilatation of the pupils; this tallies very well with the researches of Cannon and Hoskins (1911), who found in asphyxia hypersecretion of epinephrin and increase of blood-sugar.

(2) The second argument against the sympathetic theory is the fact that extirpation, or paralysis of the cervical sympathetic, does not prevent reflex dilatation [Vulpian (1879), Bumke, Weiler]; but it must not be forgotten that the emotional stimulus still reaches the adrenal glands by the splanchnic nerves and that hypersecretion of adrenalin is not prevented. Moreover all authors agree that by extirpation of the

cervical sympathetic the dilatation reflex is altered, at least the reflex on sensory stimulation. I shall afterwards return to this point. The advocates of the cortex theory see an affirmation of their opinion in the researches of those authors—e.g., Braunstein, and Parsons (1901)—who found an inhibitory influence on stimulation of the cortex cerebri, which could be prevented by cutting the n. oculomotorius. Many other observers could not obtain these results in analogous experiments; the researches of Karplus and Kreidl (1909, 1910), on the contrary, proved that there is a cerebral localization of the sympathetic reflex and that this centre is indispensable for the dilatation of the pupil after stimulation of the sciatic nerve. All agree, however, in this point, that the reflex must be localized in the cerebrum above the pons Varolii. There seems to me to be much evidence for the opinion that with the reflex in question the centrifugal stimulus is conducted from the cerebrum to the sympathetic system, at the same time affecting the cervical sympathetic and the splanchnic. Stimulation of the first will give a nearly direct response to the original stimulus. Probably the same stimuli have an inhibitory influence on the tone of the sphincter pupillæ, according to the results of the above-mentioned observers, a view in perfect harmony with our ideas about the reciprocal innervation of the sphincter and the dilator iridis. Stimulation of the splanchnic, however, causes an increase of adrenalin in the blood and reaches the eye a little later. In this way a remarkable fact stated by former examiners may be easily understood. Vulpian had already found that the quick response of the pupil on stimulation of the n. ischiadicus changed into a slower one with a longer latent period after extirpation of the cervical sympathetic; the same was found by Braunstein. But then the direct sympathetic reaction was prevented; the remaining adrenalin reaction, however, could only appear after a certain latent period. The description given by Lewandowsky of the dilatation of the pupil on injection of adrenalin is analogous to those of Vulpian and Braunstein after excision of the cervical sympathetic. I may still draw attention to the fact, that after injections of adrenalin not only is the pupil widened, but protrusion of the bulb, widening of the palpebral fissure and retraction of the membrana nictitans also occur. Precisely the same effect was seen by Vulpian on stimulating the sciatic nerve after extirpation of the cervical sympathetic. Cannon and Hoskins (1911) could indeed show an increase of adrenalin after stimulation of the sciatic nerve. For the many questions which arise in connexion with the subject, one should see the works by Braunstein, Bumke and Weiler. The scope of this article does not permit of a more detailed discussion. I was, however, obliged to discuss the principal facts in order to show that the emotional dilatation of the pupil does not form an exception to the theory of Cannon.

Darwin has already looked for the deeper reason of this reflex-dilatation. However, his remark that the brain is directly affected by the powerful emotion of fear and reacts on the pupils does not throw more light upon the question. Perhaps the solution of the problem must be looked for in the suggestion of Weiler, that in alarm the pupils of the animal were widened in order to expose the peripheral part of the retina to perception and to observe in this way surrounding objects over a wider range. I may add, that the widening of the palpebral fissure and the protrusion of the bulb would support this function of the pupil. I do not know, however, whether dilatation of the pupil causes an enlargement of the visual field in lower animals; it is probably not the case in man. Moreover, Weiler suggests that the dilatation reflex may be of use in moments of concentration of the attention (such as intensively hearing or thinking); for when we gaze in the distance we are not distracted by visual perception.

Salivary glands.—The innervation of the glandular structures offers some difficulties. Cannon discusses only the salivary glands and their innervation, together with the other parts of the digestive tract, by the cranial outflow of the involuntary nervous system (op. cit., pp. 9 and 31); doubtless the principal secretory function is bound to that division, as may be clear when we compare the copious liquid saliva obtained by stimulation of the chorda tympani with the tough, poorly secreted sympathetic saliva. Nevertheless there is evidence that these glands have also a sympathetic innervation, like the lachrymal glands, for Langley found in 1901 that injection of suprarenal extract caused secretion of all the salivary glands (op. cit., p. 126).[1] The explanation given by Gaskell of this double innervation is, that the two antagonistic systems supply with secretory fibres glandular structures which differ morphologically, part being epidermal glands and part being endodermal glands, the former being supplied by sympathetic fibres, while the latter would be supplied by connector nerves belonging to the bulbar group. In 1905, Elliot wrote that the question could "not be satisfactorily discussed until more is known of the double innervation of the salivary glands, and of the separate parts played by muscle in expelling the products of glandular activity." Eppinger and Hesz believe the salivary glands to have an autonomic innervation (the autonomic system of Eppinger and Hesz is the same as Gaskell's splanchnic division of the involuntary system); this opinion is based on the action of pilocarpine.

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[1] On the contrary, Oliver and Schäfer (1895) could not find any influence of adrenalin on the secretion of the salivary glands.

Be this double innervation as it may, it is certain that production of saliva would not be of use to an animal in rage or fear; but then it does not happen in these emotional states. For, as Cannon has pointed out, the mouth of an anxious person is dry. That the increase of adrenalin, caused by the same emotion does not give free salivary secretion may find its reason in the fact that, according to Langley (op. cit., p. 238), only large doses of the suprarenal extract are able to cause secretion of these glands. Small doses, though sufficient to cause a great rise of blood-pressure, may not have a secretory action; and indeed, the amount of adrenalin following physiological stimulation of the adrenal glands is, according to Osgood (quoted from Cannon)[1] very small.

Lachrymal glands.—According to Gaskell, a similar double innervation must be assumed for the lachrymal glands. Langley saw a free secretion from these glands after suprarenal injection in the cat, but none in the rabbit. According to Eppinger and Hesz, pilocarpine gives, besides secretion of saliva, also a flow of tears. Emotional secretion of the lachrymal glands is doubtless not a phylogenetically and ontogenetically old reflex, for lower mammals and new-born babes do not shed tears. So the emotions of fight and flight are not accompanied by secretion of tears, as may be observed with persons in rage or in active fear; usually, if weeping occurs, it comes afterwards when relaxation has followed these emotions. In emotions blood-pressure is constantly found increased; now Kornfeld (1899) has found that, whenever the secretion of sweat and of tears began, blood-pressure, which had been increased by the preceding emotions, began to fall.

Sweat glands.—According to Gaskell, sweat glands are only supplied by nerve-fibres from the thoracico-lumbar outflow (sympathetic). Langley did not observe any secretion of sweat after suprarenal injections; Elliot, however, observed that the human hand readily answered by secretion of sweat on an intravenous injection of adrenalin. There is, however, much evidence that here also the glands have a splanchnic innervation (probably from the bulbar outflow), as the secretion of sweat is much under control of vagotropic drugs (Eppinger and Hesz, "Die Vagotonie": according to them, adrenalin may even stop the secretion). Dupuy (quoted from Higier) has stated that the sweat-glands continue to secrete after the sympathetic nerve has been cut. So Higier (1917) believes it most probable that the sweat glands also have a double innervation. As is well known, all sorts of emotions (perhaps every psychical process, as may be concluded from the so-called psycho-galvanic reflex-phenomenon) may give an increase of sweat secretion. Of the emotions, which we are discussing here, perspiration is most obvious in extreme anxiety, whereas it is much less striking in rage (see also Kornfeld's observations, mentioned above). The utility of sweating is explained by Cannon in the following way (p. 203): "The evaporation of sweat helps to keep the body temperature from rising unduly from the heat of exertion. Again in strong emotion and in pain the 'cold sweat' that appears on the skin may be regarded as a reaction anticipatory of the strenuous movements that are likely to ensue."

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[1] [47], p. 198.

Genital organs.—One group of organs remains, which is, *omnium consensu*, innervated by the thoracico-lumbar outflow—i.e., the internal and partly also the external genitals. Gaskell argues that this group also does not form an exception to the rule, that the sympathetic nerves innervate only external regions; for these muscles are in part underlying the skin, in part derived from muscles surrounding the Wolffian and Müllerian ducts; now these ducts are epiblast formations and not derived from the mesoblast. The internal genital organs are supplied by sympathetic fibres only; there seems to be no trace of an innervation from the sacral outflow. The external genitals, however, are reciprocally innervated by the sympathetic system and by the pelvic nerve of the sacral division (Langley, Gaskell). Cannon (op. cit., p. 270) draws attention to the fact that the emotions which appear in these two antagonistic divisions are strikingly opposite; for fear, anxiety, and rage prevent the sexual act or cause inhibition of it in animals and man. He considers the nervi erigentes as the part of the sacral autonomic in which the peculiar excitement of sex is expressed, whereas the sympathetic division is "operated characteristically in the major emotions." This assumption would at the same time explain the opposition of emotional states such as fear and anxiety to the sexual emotions. To me, however, it seems still questionable whether we may consider the nervi erigentes as the principal or even the only route to expression of the sexual emotions. For, as Cannon himself says (op. cit., p. 271): "When the acme of excitement is approaching it is probable that the sympathetic division is also called into activity; indeed, the completion of the process, the contractions of the seminal vesicles and the prostate and the subsidence of engorged tissues, all innervated by sympathetic filaments, may be due to the overwhelming of sacral by sympathetic discharges." But, though "the sexual orgasm involves a high degree of emotional excitement, it can be rightly considered as essentially a reflex mechanism" (op. cit., p. 33). Erection, however, may often be considered as a reflex, whereas at other times it may occur automatically, without any emotion, e.g., in the morning. Ejaculation and orgasm, on the contrary, though they usually are doubtless reflexes, may sometimes take place without antecedent peripheral stimuli, but may still be accompanied by emotional reactions (pollutions). These objections, however, do not alter that other fact, mentioned by Cannon, that fear or anxiety cause inhibition of the sexual act. And it is certainly a useful thing for the animal in danger, that all energy is drawn away from the vegetative and generative functions and placed into the sympathetic (animal) system, in order to enable the individual to escape from danger.

Sphincter functions.—This brings me to the last question of this chapter. As has been mentioned above, the sympathetic system has an inhibitory influence on the small and large intestines and on the bladder, whereas it supplies with motor fibres the various sphincters (see Gaskell, op. cit., p. 43). Now, as Cannon also points out (op. cit., p. 272), the contraction of the bladder and the rectum in very intense periods of emotional stress, when the sympathetic division is strongly innervated, seems to be a contradiction to the theory advanced in the former pages. Cannon suggests that in such conditions the orderliness of the central arrangements may be upset, but this is no explanation. I might suggest that it is due to the paralysing power of sudden and extreme terror. All striated musculature may then be relaxed; the breathing is interrupted and the heart fails to act. These symptoms are all opposed to those commonly seen in rage and fear, when the sympathetic and the whole voluntary nervous system come into action. In South Africa it is a well-known fact that baboons, when they suddenly encounter a serpent, become totally paralysed; they are unable to flee, and void their excretions (see also Darwin, op. cit., pp. 146 and 292). It is also chiefly at the occasion of sudden terror that we observe the paralysis of the sphincter action in man. This view would be in harmony with Cannon's theory of the energizing power of emotions by operating the sympathetic division of the involuntary nervous system. For if activating emotions such as rage and fear mean a stimulation to all animal functions it is easily understood that a stronger emotion, such as sudden terror, may paralyse them; it would only be an example of the well-founded biological rule, that a stimulus may cause paralysis on becoming stronger.

Tonus of Striated Musculature.—Finally, I want to mention, for the sake of completeness, the influence which the sympathetic system might possibly have on the tone of the skeletal muscles. It was shown in 1913 by de Boer that resection of the rami communicantes produced a loss of tone in the striated musculature of the frog; these results could also be obtained with cats. The experiments of de Boer were confirmed by Mansfeld, Lukács and Ernst (1915), who examined the chemical tone of striated muscles. Dusser de Barenne (1917) and von Brücke (1918), however, hold the opinion that the influence of the thoracico-lumbar outflow of the involuntary nervous system (sympathetic) on the muscular tone is of small importance only. In studying the literature on this subject one gets the impression that the sympathetic nerve has indeed some influence on the tonus of striped muscles, but that there are also other influences which regulate the muscular tone independent of the sympathetic system. As this question, however, is still undecided and as we have no exact observations, as far as I know, on the muscular tone in mental disorders (which might serve as a comparison) I shall not enter into a deeper discussion of the subject.

CHAPTER III.—THE SYMPATHETIC SYSTEM IN MELANCHOLIA.

So the question remains to be answered, whether in psychiatry there are more signs of sympathetic stimulation besides the increase of blood-sugar (see p. 254). As I have made a closer study of the blood-sugar in melancholia, and as we also have the most reliable information about bodily changes in this disease, I have chosen melancholia for testing this question. I want to declare emphatically that I make no claim to be complete; there may also be other psychoses with symptoms of increased sympathetic innervation, e.g., amentia; I have only taken melancholia as an example.

Intestinal Disorders.

Under this title I shall also discuss the *salivary glands* and for convenience' sake together with them the *sweat glands* and the *lachrymal glands*. Whether these glands are supplied with secretory fibres chiefly by the splanchnic or by the sympathetic division, or finally by both systems, is a question which I have discussed on pp. 259-260.

In the emotional states which cause an increase of sympathetic activity, we certainly find inhibition of salivary secretion, there is no sign of lachrymal secretion, and sweating is a process which is combined rather with the paralysing than with the activating kinds of emotions which operate the sympathetic system. All these secretions are often diminished in melancholia; by most authors this fact is considered to be an example of the general inhibition. The inhibitory influence of the disease would not only appear in the well-known motor inhibition, but also in the decrease of secretions, of the intestinal movements and of the pulse. That this conception is wrong may be directly deduced from the fact that secretions and intestinal movements are diminished most in cases of anxiety, in which there is no question of a general inhibition. That salivary secretion is often diminished in melancholia was observed by several psychiatrists (e.g., Ballet, 1903, Ziehen, 1908, Church and Peterson, 1914), though a stuporous melancholic may give the impression of increased salivation by retaining the saliva in his mouth for a long time. It is, however, quite different from the true salivation in a catatonic stupor. Of course this is a difficult subject for exact examination.

We find in nearly all text-books the observation that weeping is very seldom seen with melancholia. Also in the anxious form, *lachrymal secretion* is usually totally absent, patients even complain of being unable to weep (Ziehen, Kraepelin, 1913, Stransky, 1911). The *secretion of sweat* and its relations to the sympathetic division and the discussed emotions are a problem of some difficulty, as is explained on p. 260. Most authors speak of a dry, scaly skin in melancholia (Ziehen, Kraepelin, Stransky), Bruce and de Maine Alexander (1900) mention a dry skin in the acute form (amentia?).

Gastric Secretion.

Through the fundamental experiments of Pawlow (1898) we know the activating influence of special sensory and psychical stimuli of an agreeable kind on the salivary and gastric secretion. This fact also holds good for man, as was proved by A. Bickel (1906), Cade and

Latarget (1905), and Herz and Sterling (experiments with gastric fistulæ in man). On the contrary, it appears that emotions, such as worry, fear and anger, have a strong inhibitory influence on the secretion of gastric juice in the dog (A. Bickel and Sasaki, 1905), and even on the secretion of pancreatic juice and bile (Oechsler, 1914, quoted after Cannon, op. cit., p. 13). It is also a fact that the sensory and psychical stimuli which cause secretion of gastric juice are conducted by the vagus nerve (Pawlow); whether it is the splanchnics that conduct the inhibitory stimuli in fear and anger is still undecided. Most examinations we possess on the gastric secretion in melancholia are of older date. The first to study the question was von Noorden (1887), who concluded that in melancholia the amount of HCl is increased, that the emptying of the stomach is accelerated, and the digestive power of the juice is normal. Most of von Noorden's cases, however, were not suffering from maniacal-depressive insanity or from simple melancholia, but from dementia præcox, confusional insanity, and other psychoses. So, although these examinations were carefully performed, we cannot use them for our present problem. And this is the case with most other publications of older date. Of the eleven observations by Pachoud (1888), there are only four (Observation V, VI, VII and XI) which, according to our present conception, might be cases of melancholia. Of Orliac's (1892) six cases only the first belongs to this form of insanity; this one showed a low amount of HCl. Pachoud fully agrees with von Noorden. Placzek (1890), on the contrary, who examined eight cases of melancholia (all probably true examples of the disease, except No. 8), found a very low percentage of HCl and a slow emptying of the stomach. The results of Leubuscher and Ziehen (1891) varied, the cases of melancholia showing hypo- and hyper-acidity and also normal conditions. In the same way Bell (1909) found partly subnormal, partly hypernormal amounts of HCl in melancholia. Cowie and Inch (1905) observed in 81·8 per cent. of their twenty-two cases hyperacidity; they found the digestive power of the gastric juice increased, though it is not secreted in large quantity. E. Mayr (1907) and Togami (1913) also paid attention to the secretion of pepsin and rennin. Mayr does not speak of melancholia specially, but he combines all psychogenous mental disorders, in which anxiety psychoses (also melancholia?) are included. In these he finds a high amount of HCl and a very small amount of pepsin, and also only a little rennet. According to Mayr, these conditions are characteristic of all emotional states. Togami has obtained about the same results. Of his six cases of melancholia, however (of which the first case, No. 21, surely is not a good example of melancholia), only two (Nos. 23 and 26), show a hyperacidity, whereas Nos. 24 and 25 have a rather low percentage of HCl, and No. 22 a normal amount. The amount of pepsin, however, examined by the edestin reaction, was found to have constantly decreased; indeed, pepsin is often nearly absent. Summing up, we can say that the question of the percentage of HCl is still undecided.

In addition to the fact that various authors have examined different forms of insanity, there are still other reasons for the incongruity of the above-mentioned results. First of all, the meals used by the patients were different, and thus at the same time the chemical and psychical stimuli for gastric secretion. Secondly, we must not only look for a change of the quality of gastric juice, but also for the quantity; for A. Bickel (1906) has shown that the amount of HCl is fairly constant, whereas the quantity is increased or diminished in different psychical states. The amount of pepsin, however, is almost constantly found to be decreased. At any rate we may take it for granted that emotions such as worry, fear and anger have a strong inhibitory influence on gastric secretion, not only in animals, but also in normal persons. The instances of Hornborg (1904), of Bogen (1907), and of Herz and Sterling, all experimenting on gastric fistulæ in man, have put the question beyond doubt; Grandauer's researches (1911) are a valuable confirmation of these experiments.

Motility of the Intestine.

The same can be said of the influence of worry, fear and anger on the motility of the stomach and of the small and large intestines. This too we owe to the researches of Cannon and his school. Cannon found in 1898 that these emotions caused inhibition of the peristalsis of the stomach; by means of Röntgen-rays he proved in 1902 that the same was the case with the small and large intestines. "Like the peristaltic waves in the stomach, the peristalsis and the kneading movements of the small intestine all cease whenever the observed animal shows signs of emotional excitement. (Cannon, 1918, op. cit., p. 16.) These observations are not only true for the cat, but also for the dog, the rabbit and the guinea-pig; they are confirmed by other authors (Lommel, 1903; Auer, 1907; Katsch, 1913). On the contrary, the emotion of seeing the desirable food is, as with gastric secretion, sufficient to cause peristalsis of the stomach (Best and Cohnheim, 1910) and of the intestine (Katsch, 1913). Now the vagus nerve supplies with motor fibres the stomach and the small and large intestines (see also the experiments of Cannon, 1906); the splanchnic (sympathetic division) sends inhibitory fibres to the same muscles and motor fibres to the various sphincters (Gaskell). Accordingly the injection of adrenalin causes a sudden stoppage of the movements and at the same time anæmia of the whole intestine (Katsch, 1913). As the vagus is without doubt the motor nerve for the stomach and the small intestine, it is almost certain that the psychical stimuli which cause peristalsis[1] are conducted by this nerve; the direct proof, however, is not yet given, as far as I know. That it is the sympathetic system which conducts the inhibitory stimuli dependent on fear, anxiety, &c., is very probable. Katsch saw through his "experimental abdominal window" when the animal (rabbit) was startled, e.g., by the sudden fall of a heavy object, that the intestine suddenly became quite pale and absolutely motionless; it is, as he writes, "as if we had made an intravenous injection of adrenalin; in quite the same way the inhibitory influence of terror acts by means of splanchnic stimulation." Indeed, the paleness accompanying the motor inhibition makes it certain that it is the splanchnic nerve which conducts the inhibitory stimuli of emotion. Katsch saw the same effect from pain; in accordance with Cannon's researches, who found the same reactions of sympathetic stimulation and of increase of adrenalin-secretion in pain and in fear and anger. Hotz (1909) found that the inhibitory influence of dis-agreeable sensory stimuli is bound up with the splanchnic, for it is absent after splanchnic section. The brief remarks of Fubini (1892) and Esselmont (1899), who observed an activating influence of emotions such as fear on the intestinal motility, in my opinion cannot upset the well-founded and often confirmed conception of Cannon.

Whereas it is certain that the mechanism of gastric secretion is the same in animals and man, we have but little proof of the inhibitory influence of emotion on intestinal motility in normal man. Rosbach (1890), however, observed in a woman with an anterior colotomy and with a remarkably thin abdominal wall (so that he was able to study the influence of various stimuli on peristalsis in the same way as Katsch

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[1] The word peristalsis is not used in the sense of a contraction of the gut above a food mass and a relaxation below it, in contradistinction to the other intestinal movements, such as pendular and rolling movements, but in the general sense of movements of the intestinal tract.

No.	Sex	Age	Name	Constipation	Prescriptions	Remarks on psychical state
1	F.	43	S. D. B. ..	2·3	No purgatives, 3 × 40 mg. opium p. d.	Slight case, no anxiety, bed; P.
2	F.	72	Mrs. S. ..	2·1	4 × lax., no opium ..	Slight case, no anxiety, bed; P.
3	F.	52	Mrs. Sch. ..	2·3	No lax., no opium ..	Marked anxiety, walking; P.
4	M.	78	P. P. ..	3·5	6 × lax., ± 13 mg. opium p. d.	Marked anxiety, bed; P.
5	F.	36	Mrs. Sc. ..	1·3	No lax., no opium ..	No anxiety, bed; P.
6	F.	72	Mrs. B. ..	2·0	No lax., no opium ..	No anxiety, bed; P.
7	M.	18	D. R. ..	1·5	No lax., no opium ..	Stupor, bed; I.
8	F.	60	Mrs. H. ..	1·2	No lax., no opium ..	No anxiety, bed; I.
9	M.	48	H. F. ..	1·1	No lax., 3 × 40 mg. opium p. d.	No anxiety, bed; P.
10	M.	50	H. N. ..	1·2	1 × lax., no opium ..	No anxiety, bed; I.
11	F.	30	Mrs. V. ..	1·5	No lax., no opium ..	Slight case, no anxiety, bed; I.
12	M.	43	H. B. ..	2·7	8 × lax., no opium ..	Sometimes marked anxiety, bed; I.; otherwise motor inhibition
13	M.	26	J. H. ..	1·5	No lax., no opium ..	Marked anxiety, bed; P.
14	F.	40	Mrs. M. ..	1·1	No lax., no opium ..	Slight case, no anxiety; I.
15	F.	55	K. S. ...	1·3	No lax., 3 × 60 mg. opium p. d.	No anxiety; bed; I.
16	F.	63	Miss P. ..	1·1	No lax., no opium ..	No anxiety, walking; P.
17	M.	43	J. v. R. ..	1·5	No lax., no opium ..	No anxiety; I.
18	M.	52	F. F. ..	1·0	No lax., no opium ..	No anxiety, bed; I.
19	F.	35	G. K. ..	1·2	No lax., ± 15 mg. opium p. d.	No anxiety; I.
20	M.	55	W. v. D. ..	2·1	6 × purg. p. m., + 2 × lax. p. d., 5 × 50 mg. opium p.d.	Permanently slight degree of anxiety, bed; I.
21	M.	61	W. S. ..	2·7	5 × purg. p. m., + 1 × lax. p. d., no opium	Marked anxiety, could scarcely stay in bed; P.
22	M.	46	D. A. ..	3·2	9 × purg. p. m., + 1 × lax. p. d., 3 × 60 mg. opium p. d.	Very anxious, could scarcely stay in bed; P.
23	F.	50	A. G. S. ..	4·7	5 × lax. p. m., 3 × 60 mg. opium p. d.	Anxiety + motor inhibition, glycosuria, bed; P.
24	F.	44	H. L. ..	2·0	6 × lax. p. m., no opium	Stupor, no anxiety, partly in bed, partly walking about; P.
25	M.	26	O. P. ..	2·0	1 × lax., no opium ..	Not anxious, bed; P.
26	M.	43	B. D. ..	1·6	No lax., no opium ..	Not anxious, bed; P.
27	M.	65	H. B. ..	2·3	1 × lax., no opium ..	Anxiety, glycosuria; I. disappearing on recovery, bed
28	F	48	M. M. ..	2·0	1 × lax., 2 × 70 mg. opium p. d.	Slight degree of anxiety, partly in bed, partly walking about; P
29	F.	47	M. D. O. ..	3·4	3 × lax., 4 × 60 mg. opium p. d.	Very anxious, walking about; P.
30	F.	50	H. F. H. ..	1·2	No lax., no opium ..	No anxiety, bed and walking; P.
31	F.	29	R. P. de V. ..	2·4	1 × lax., no opium ..	Slight degree of anxiety. bed; P.
32	F.	56	H. B. B. ..	2·8	7 × lax., no opium ..	Marked anxiety, bed; P.
33	F	34	D. O. D. ..	1·3	No lax., no opium ..	Soon convalescent, no anxiety, partly in bed, partly walking about; P.

No.	Sex	Age	Name	Constipation	Prescriptions	Remarks on psychical state
34	F.	61	L. S. B.	2·8	2 × lax., 4 × 50 mg. opium	Anxiety, bed; P.
35	F.	45	A. K. H.	1·4	No lax., no opium	Not anxious, bed and walking; I.
36	M.	45	H. Ph. R.	2·5	8 × lax., no opium	Anxiety and motor inhibition, bed; P.
			Same patient	1·0	Half glass of apenta p. d., no opium	No longer anxious, motor inhibition, bed
37	F.	30	R. de V.	1·9	No lax., no opium	Not anxious, bed; P.
38	M.	57	K. R.	1·4	2 × lax., no opium	Not anxious, bed, walking; P.
39	F.	40	A. G.	2·0	2 × lax., no opium	Not anxious, walking about; P.
40	F.	51	G.v. d.V.v.D.	2·8	1 × lax., no opium	Anxiety, bed; P.
41	F.	41	B. M.	2·2	6 × lax., 4 × 40 mg. opium p. d.	Not anxious, bed, walking; P.
42	M.	50	K. V.	1·3	No lax., no opium	Not anxious, bed; P.
43	F.	54	G. D. J.	1·3	No lax., no opium	Not anxious, a single time excepted, bed; P.
44	F.	51	K. M. v. d. K.	1·4	No lax., no opium	Not anxious, bed; P.
45	M.	38	A. v. O.	1·0	No lax., no opium	Not anxious, bed; I.
46	F.	45	W. M. L.	1·5	No lax., no opium	Not anxious, bed, walking; P.
47	F.	33	J. B. v. d. W.	2·8	8 × lax., 3 × 30 mg. opium p. d.	Anxiety, could scarcely stay in bed; P.
48	F.	29	G. R.	1·5	No lax., no opium	Not anxious, bed, walking; I.
49	F.	52	E. B. v. d. P.	2·3	1 × mild lax. p. d., 3 × 40 mg. opium p. d.	Anxiety, could scarcely stay in bed; P.
50	F.	44	H. S. S.	1·6	5 × lax., no opium	Stupor, no anxiety, bed; P.
51	F.	59	H. N. S.	1·7	2 × lax., no opium	No anxiety, bed; P.
52	F.	52	H. W. G.	2·4	6 × purg p. m. + 1 × lax. p. d., no opium	Anxiety, bed; P.
53	F.	50	C. K. B.	3·7	9 × lax., 3 × 60 mg. opium p. d.	Anxiety, bed; P.
54	M.	58	B. J. D.	2·0	No lax., no opium	No anxiety, bed; P.
55	F.	41	B. F. de L.	3·1	6 × lax., 3 × 50 mg. opium p. d.	Anxiety, bed; I.
56	F.	41	A. H.	1·9	1 × lax., 3 × 50 mg. opium	Slight degree of anxiety, mostly calm, bed; I.
57	M.	45	D. L.	3·3	7 × lax., no opium	Anxiety, could scarcely stay in bed; P.
58	M.	47	W. W.	1·4	No lax., no opium	Not anxious, bed; P.
59	M	44	E. de H.	4·0	4 × lax., no opium	Anxiety, bed, P.
60	M.	43	H. L.	1·2	No lax., no opium	Not anxious, bed, walking; I.

P = Periodical melancholia.
I = Melancholia for the first time, but recovered on leaving the hospital.
Purg. = stronger purgative, such as oleum ricini, cascara, clysma, &c.
lax. = mild purgative, such as saline waters, which may be given to the patient every day.
p. m. = during four weeks.
p. d. = pro die.

could by means of his "Bauchfenster") that with emotions such as fear and worry all movements of the intestinal tract suddenly ceased; this inhibition lasted for five till ten minutes. The same emotion never caused peristalsis to start in the formerly quiescent bowel.

What do we know of this influence in mental disorders, especially in melancholia? Of the motor power of the stomach in melancholia we have little information. Bruce and de Maine Alexander observed a weak motor power in acute melancholia, but probably their cases were amentia. Placzek found the same in cases of presumably true melancholia, whereas van Noorden and Pachoud found the emptying of the stomach accelerated. I have already criticized these publications on p. 265. With the knowledge of the general effect of adrenalin or stimulation of the sympathetic and of emotions such as fear and fright, both on the motility of stomach and the intestines, and of the weak motor power of the small and large intestines in melancholia, it seems probable that the motor power of the stomach is also inhibited in this disease. The researches of Holzknecht (1911), who found by means of the Röntgen ray's a decrease of tone of the œsophageal wall in cases of "Cyclothymie" (mild form of maniacal-depressive insanity), also point in this direction.

The inhibition of the intestinal motility is so widely known and so generally admitted, that I need not mention any literature on the subject. One can find it described in every text-book as a symptom characteristic of melancholia. It is generally attributed to the typical motor inhibition and general want of movements of the patient. With our knowledge of the above-mentioned physiological facts, it is superfluous to emphasize the improbability of this explanation. But the clinical data are also unfavourable to this conception. Firstly, we may find the symptom in mild forms of the maniacal-depressive insanity (cyclothymia, Willmanns, 1906, Roemheld, 1908), in which we do not find any motor inhibition of importance, but chiefly depression, and at the same time agitation and restlessness. But then we may find obstinate constipation in cases of anxious melancholia, though these sufferers move restlessly all day long. I have examined the morbid histories of sixty cases of melancholia I observed; I have only chosen periodical cases, and, of patients who had their first attack only, those who had recovered completely on leaving the hospital. I must emphatically state that I have chosen cases of true melancholia only; none of them suffered from dementia, from confusion or hallucinations or from symptoms which might suggest dementia præcox; all bodily

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when the patients are in an emotional state. Haškovec (1905), e.g., found it increased in the emotional form of neurasthenia; Heim (1900) in neuropathic children, and Alter in emotional cases of dementia præcox. The results with mania are much less constant than those with melancholia, as may be seen from the above account. It is the same problem as I have discussed in the first chapter, when speaking of blood-sugar in mania. First there are the same difficulties with the examination itself. Cases of real mania are rather rare and as even small muscular labour causes a marked increase of blood-pressure, the results in mania cannot be very reliable. At any rate it is impossible to examine maniacal patients regularly at the same time every day, as they are often restless to such a degree as to make all investigation impossible. But even if we do not consider this bodily reason, there remain the mental causes for a varying blood-pressure; for the maniacal patient is now calm and optimistic and then again restive, furious and highly excited. This must be the reason that the results of the various authors as regards the blood-pressure in mania differ so greatly. Just as blood-sugar is increased in the highly emotional form of mania, so also blood-pressure is raised in the same conditions.

Plethysmographic and Sphygmographic investigations.—As we have seen, injections of adrenalin or stimulation of the sympathetic are followed by a rise of blood-pressure; we know that in emotional states the sympathetic system is over-excited and we also know that the same emotions cause an increase of blood-pressure. It is easy to see in these facts a causal connexion.[1] A direct proof, however, is wanting. I have looked for this proof in the plethysmographic investigations, for the latter were made after adrenalin had been injected, and in the case of emotions with normal persons, and in psychoses. According to Cannon (1918, op. cit., p. 200), the studies of volume changes in parts of the body, made by Oliver and Schäfer, showed that injected adrenalin drove the blood from the abdominal viscera into the central nervous system, the lungs, the heart, and the active skeletal muscles. Oliver and Schäfer (1895) themselves are a little more reserved: "It may fairly be assumed that although we are unable to record any plethysmographic observations upon the intestines, the great rise of blood-pressure, which invariably follows the injection of the extract, is in all cases due very largely to the contraction of the arterioles of the splanchnic area" (op. cit., p. 246). Strong evidence in favour of the opinion that the emotional rise of blood-pressure in animals is really caused by increased adrenalin-secretion, is given by the experiments of von Katsch (1913) who, with the help of his experimental abdominal window observed a sudden pallor and stoppage of the intestines, as well after injection of adrenalin as after sudden emotions.

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[1] Pain, which has the same sympathetic reactions as anger and fear—as pointed out by Cannon—also gives a marked increase of blood-pressure (see, e.g., H. Strauss, 1901).

With man we have many plethysmographic investigations. E. Weber (1910), and after him H. Bickel (1916), studied the changes of volume of the intestines, the cerebrum and the extremities in man during various psychical processes. According to them, there would be a certain antagonism between the external parts of the body and the intestines; the volume of the arm and of the ear would decrease and that of the bowels would increase in the case of intellectual work, or when the attention is fixed upon a sensory stimulus or if the person is unpleasantly struck by the sensory stimulus ("sensorielle Aufmerksamkeit" and "sensorielle Unlust"). On the contrary, the volume of the arm would increase and the volume of the intestines would decrease in the case of pleasant feelings (Weber). These facts are apparently contradictory to our conception given above. That the volume of the arm shrinks in emotions would be no obstacle, for the smaller arteries are contracted by adrenalin; Oliver and Schäfer found as the usual result of their injections a decrease of the volume of the limbs. But the increase of the intestinal volume is a difficult point.[1] One might suppose that strong emotions, such as fear and anger, have other bodily reactions than the slight emotions caused by sensory stimuli or intellectual work. Weber, however, found the same increase of the intestinal volume in sudden terror. Yet I do not think these results to be sufficient proof against our theory; the striking constriction of the intestinal vessels in emotions, directly seen by Katsch, is too much in favour of it. Weber's method of studying the intestinal vascular volume demands many precautions. Professor Wiersma told me that he could not obtain any reliable results by the same method. I doubt whether the author has sufficiently considered the influence of emotions on the intestinal musculature, either of the wall or of the sphincter ani. As Weber brings a balloon of rubber into the rectum (the balloon is then blown up and is connected with a kymograph by a little tube), it is clear that contraction, relaxation and tone of rectum and anal sphincter may influence the pressure of the air in the balloon and cause their special changes in the plethysmogram.

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[1] In muscular labour, even if only the intention to move exists (Weber, 1913), we see a general widening of the muscular vessels and constriction of the intestinal vessels. It needs no explanation that this is very useful for man and animals in the way pointed out by Cannon.

The sphygmogram is no more capable of solving the problem. Wiersma[1] (1911-13) found that the irregularities, which are normally caused in the sphygmogram and in the plethysmogram by respiration, disappear in preoccupation and emotions; the same is found in mania and in melancholia, especially in anxious melancholia. As we do not know whether the same occurs in sympathetic over-excitement, and as therefore a comparison is impossible, these investigations cannot help us to solve our problem. But it shows once more that it is the emotional side which causes the bodily changes in melancholia, not the inhibition; in stupor the curve shows the same regularity, even then the melancholic is highly emotional; this also explains the high blood-pressure and the increase of sugar in the blood in melancholic stupor. We often had the occasion to note the similarity of the bodily changes in mania and in melancholia, both dependent on an increased emotional state. These investigations by Wiersma confirm this conception. Ziehen also (1908) had observed that the plethysgmographic curves in mania and in melancholia are much like each other, if the maniacal excitement is well pronounced (op. cit., p. 601). Summing up, we may therefore state that the rise of blood-pressure is very probably due to an over-excitement of the sympathetic system, but that the absolute proof is wanting.

The question of the *pulse-rate* still remains to be discussed. Though it is the usual text-book statement that it is decreased in melancholia, in this general sense it is doubtless incorrect We may find a slow pulse in melancholia, even in the anxious form, but more often it is accelerated. P. Weber (1910) showed that on an average the pulse-rate is increased both in melancholia and in mania. These facts are in perfect harmony with our conception about over-excitement of the sympathetic division in melancholia. For adrenalin causes an increase of rate of the isolated heart; if, however, adrenalin is brought into the circulation of a normal animal, it causes at the same time constriction of the smaller arteries and consequently a rise of blood-pressure, which has a depressive influence on the heart-rate. Hoskins and Lovelette have proved (1914) that in the same animal injection of adrenalin may cause an accelerated pulse, if the blood-pressure had not risen too much, and a decrease of the pulse-rate if the blood-pressure had become very high. In most of their cases, however, they observed an increase of the pulse-rate together with an increase of blood-pressure.

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[1] These results are confirmed by Küppers (1913). Ziehen, Saiz (1907) and H. Bickel, on the contrary, observed very pronounced respiratory oscillations in emotions and in the maniacal depressive psychoses. The large number of curves made in many normal and pathological cases by Wiersma, all showing a regular pulse in emotions, have convinced me that this fact is beyond a doubt. Moreover, they have been confirmed by the simultaneous registration of the psycho-galvanic reaction (Wiersma, 1915).

Reflex Dilatation of the Pupil.

All psychical processes cause a widening of the pupil; anxiety may do so in a high degree. It is a well-known fact that anxious persons have large pupils, and all mental diseases in which anxiety occurs show this phenomenon. Observations of this kind in melancholia can only be found scattered about in literature; Bumke mentions a case of anxious melancholia in which the pupil was every now and then dilated to such a degree that even the light reflex could no longer be obtained. The only systematic investigation of the size and reactions of the pupil in melancholia known to me is that by Weiler, who examined principally stuporous states of maniacal-depressive psychosis. He never found miosis, but, on the contrary, often mydriasis. The psychical reflexes, even in complete stupor, were never absent; but in 10 per cent. the reactions were not well pronounced, and these were the doubtful cases with paranoid symptoms; in the cases of typical melancholic stupor, however, the psychical reactions were always very easily and clearly obtained. This is again a marked difference from catatonic stupor. Van der Scheer (1915, op. cit., p. 469) found that the adrenalin-mydriasis is frequent in maniacal-depressive insanity; the number of cases examined, however, was small. Mydriasis after instillation of adrenalin in the eye is a rather intricate reaction. A. Loewy and Rosenberg (1914) found that the so-called "O. Loewisches Pupillenphänomen" (i.e., adrenalin-mydriasis in the dog after extirpation of the pancreas) was present in all cases of experimental hyperglycæmia; in this way the phenomenon would not have the meaning of a specific reaction on sympathetic over-excitement. Pötzl, Eppinger and Hesz (1910) have tested O. Loewi's phenomenon in different forms of insanity; their results with the maniacal-depressive psychoses were varying; in some cases the reaction was strikingly positive, in other cases it was negative.

Conclusions.

We have found in melancholia many signs of over-excitement of the sympathetic system, or of hypersecretion of adrenalin. In many points this problem is still undecided, and we often saw reason to conclude that the final proof was wanting. I do not therefore put forward this conception as a solidly based theory, but as a working hypothesis only.

I am aware of the fact that I have not solved the problem in all its details; but I believe that the principal bodily changes in melancholia can better be understood now that they have been observed from one point of view. For I think it certain that they are all dependent on the highly emotional character of the disease, not only the increased blood-sugar, but the intestinal disorders, the rise of blood-pressure, and the dilatation of the pupils. In this respect it does not differ so much from mania as has often been supposed, at least not from the fully excited form. For in both conditions, in melancholia and in mania, the increased emotionalism is the principal point. We again find it in the character of the patients, even in their normal state, and in the character of many of their relatives. Emotionalism is the most constant symptom of both diseases, for it is found in stupor of melancholia as well as in its restlessness and anxiety; we find it in mania and also in the mixed form of the disease, which forms the connecting link between the two apparently so different phases. Emotionalism makes melancholia and mania an undeniable entity: the maniacal-depressive psychosis and the various bodily reactions, discussed in this paper, are its direct consequences.

It is not surprising that these reactions are most constant in melancholia. For the emotions of a depressive character are, phylogenetically spoken, old, and they have been provided with the bodily reactions which are useful to the animal in attack, defence or flight. I may here draw attention to the remarkable fact that the depressive emotions of the melancholic and the excitement of the maniacal are essentially different from the grief and the joy of normal persons. For melancholic depression is always mixed with a certain agitation and anxiety, maniacal excitement with a certain irritability, a tendency to resist or to fight.

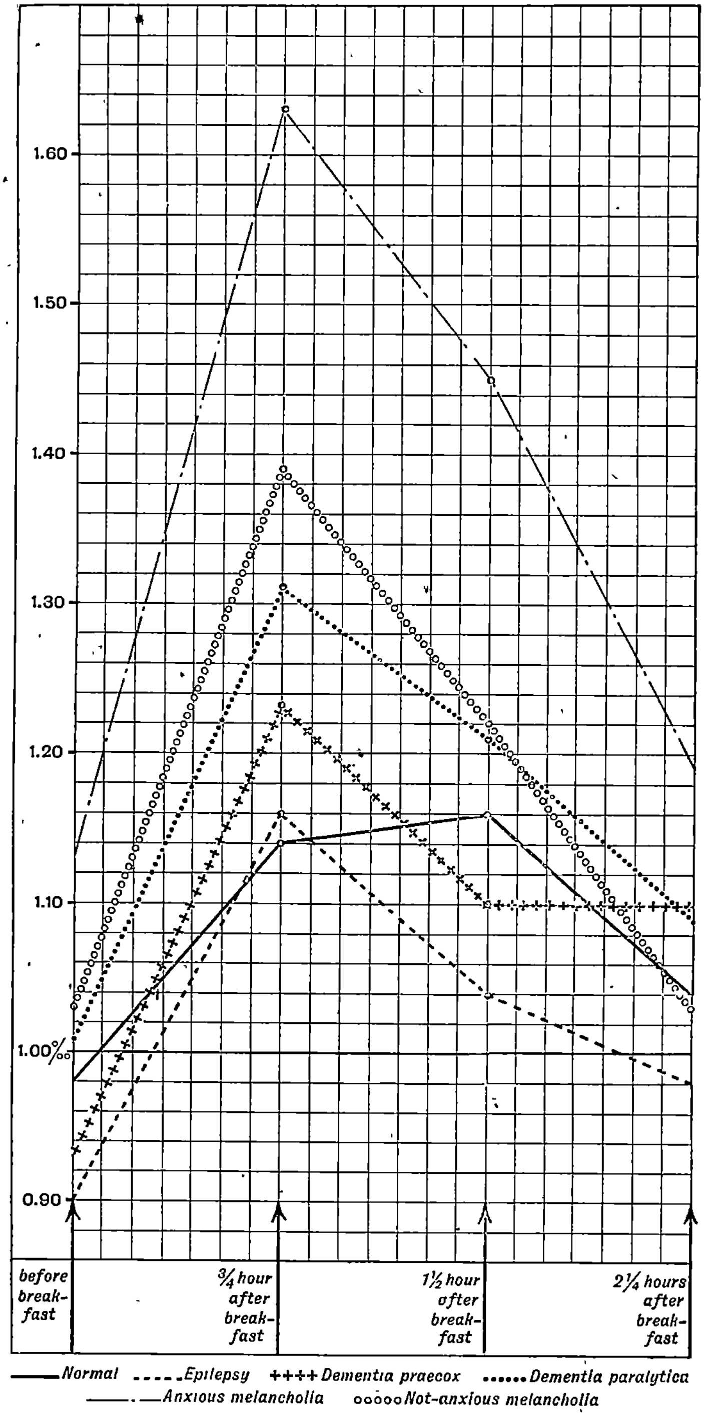
The attacks of the maniacal-depressive psychosis overtake their victims without our being able to perceive any real corporeal or psychical reason. Would not phylogenesis help us to find the deeper ground of this disease, which is degenerative katexogen? And is not it a remarkable fact that in this very disease we can observe so many of the old animal emotions with their appertaining bodily reactions?

RÉSUMÉ.

Emotions, especially those of a depressive character, cause an increase of blood-sugar. They therefore have a deteriorating influence on diabetes mellitus. They may cause a temporary hyperglycæmia and even glycosuria in normal persons, not suffering from saccharine diabetes. We can no longer stick to any fixed limit of the amount of sugar in the blood, above which we diagnose diabetes. It is the same as with the body-temperature. It is incorrect to consider a temperature of 37° or even 37·5° C. abnormal. There are many persons —and especially those of a neuropathic constitution—who have a higher temperature (e.g., 37·8°, 37·9° C.) without any bodily reason. In the same way, even a considerable increase of blood-sugar need not be a symptom of disordered metabolism. One often gets the impression that these persons temporarily (emotions) or permanently (e.g., in the tropics) live on a higher level; in that case, glycosuria does not appear—though the blood-sugar is increased to such a degree as to cause glycosuria in normal condition—for the high amount of blood-sugar means no abnormal condition in the organism.

In the same way, hyperglycæmia may occur with any emotional state in mental disorders; this has been found by various observers and also by myself in emotions with patients suffering from general paresis, epilepsy, dementia præcox, traumatic neurosis and neurasthenia. Glycosuria and hyperglycæmia are most frequent in melancholia.

The present investigation has proved that hyperglycæmia before breakfast (spontaneous hyperglycæmia) is not a constant symptom in melancholia, but this symptom is constantly found after the patients had taken ± 200 c.c. of milk and ± 100 grm. of bread and butter (alimentary hyperglycæmia). It was shown that with marked anxiety there was the highest amount of sugar in the blood. The figure on p. 281 shows the various curves of blood-sugar before breakfast, three-quarters of an hour after breakfast, one and a half hours after breakfast, and two and a quarter hours after breakfast. The curve of epileptic dementia shows a rather low amount; that of hebephrenia only surpassed the normal curve three-quarters of an hour after breakfast. The curve of paralytic dementia is doubtless


1.60
1.50
1.40
1.30
1.20
1.10
1.00‰
0.90
before breakfast
¾ hour after breakfast
1½ hour after breakfast
2¼ hours after breakfast
—— Normal
- - - - - Epilepsy
++++ Dementia praecox
•••••• Dementia paralytica
——·—— Anxious melancholia
ooooo Not-anxious melancholia

higher than the normal one; probably the anatomical alterations of this disease are responsible for the increase. A high and steep curve is that of melancholia; the curve of anxious melancholia is the only one that starts much higher than the normal curve; there is a marked difference between the anxious and the not anxious forms of melancholia. No curves are given of the amount of blood-sugar in amentia and in mania; amentia is so little an entity and the percentage of sugar in the blood of maniacal patients is too variable. As for the reason of this variability, I must refer to my discussion of it in Chapter I (pp. 246 and 251); suffice it here to state that mania also shows a distinct increase of blood-sugar in highly emotional states, in anger and irritability.

It is shown by Cannon, Shohl and Wright that in animals strong emotions, such as fear and anger, cause glycosuria; this glycosuria is the direct consequence of an increase of sugar in the blood, and this hyperglycæmia again is caused by a hypersecretion of adrenalin. Cannon has pointed out that hyperglycæmia is not the only consequence of the increased adrenalin in the blood (or, which is the same thing, of the over-excitement of the sympathetic system), but that in the major emotions, in anger, fear and pain, the total sympathetic division is hyper-stimulated. All these sympathetic reactions mean so many useful things to the animal in danger.

Gaskell divides the nervous system, the involuntary as well as the voluntary one, into a somatic and a splanchnic part. The motor part of the somatic division would in this way supply the skeletal muscles and the unstriped musculature belonging to the sympathetic (thoracico-lumbar outflow). Combining the physiological conception of Cannon with the anatomical conception of Gaskell, we may come to the natural hypothesis that in moments of danger the whole somatic nervous system comes into action, whereas the splanchnic system serves for conservation of the body, or, to express it simply: the somatic division serves the outer man, the splanchnic division serves the inner man.

Cannon found many symptoms of over-excitement of the sympathetic division in emotion, all of which were useful to the animal. When we look for the other reactions on sympathetic stimulation, it appears that they are all present in emotion and they may all be of use. It is easily understood that emotions such as anger and fear have preserved their old animal reactions in man also, and that these reactions are most frequently found in melancholia. Indeed, we may find in melancholia many symptoms of over-excitement of the sympathetic division, increase of blood-sugar, high blood-pressure, dilatation of the pupils, diminishing of secretions and inhibition of the intestinal movements.

These observations lead to a further conclusion. The deeper cause of melancholia, and especially of maniacal-depressive insanity, of periodical melancholia, of the circular type of the lighter form, the so-called cyclothymia, in short, of all those degenerative psychoses in which we find that inexplainable variability of mood, must be sought in the animal world. In this way, the frequency of the old animal reactions in melancholia may be better understood.

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EDITOR.

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BRAIN.

PART IV, VOL. 42.

SUGGESTION AND SUGGESTIBILITY.[1]

BY E. PRIDEAUX.

§ 1.—DEFINITIONS OF SUGGESTION.
§ 2.—VARIETIES OF SUGGESTIBILITY.
§ 3.—CLASSIFICATION OF THE RESPONSES TO SUGGESTION.
§ 4.—ABNORMAL SUGGESTION.
§ 5.—SUGGESTION AS A METHOD OF TREATMENT.

§ 1.—DEFINITIONS OF SUGGESTION.

THE controversies between psychologists and neurologists as to the nature and treatment of the psycho-neuroses are largely due to the employment by both parties of the same words in different senses, and, as a striking instance of this, the word "suggestion" has been responsible for considerable confusion. For many neurologists suggestion is the beginning and the end of all diseases of psychogenetic origin, both as an ætiological factor and as a method of treatment. Even amongst psychologists there seems to be no real agreement as to the meaning of the word, and it is often used as if it were an explanation for a mechanism which is not understood.

The various definitions which have been given of the term "suggestion" make it obvious that different degrees of the same process are being referred to. These definitions can be divided roughly into two classes according as they refer to: (*a*) *Normal suggestion*, which takes place in everyday life in all of us; or (*b*) *Abnormal suggestion*, which takes place in psychoneurotic patients, and in normal persons under abnormal conditions. It is difficult to draw any hard-and-fast line between the two, for the difference is one of degree only, and appears to depend on the individual tendencies of the subject, whereas the mechanism remains the same in both classes. The term "suggestion," as used by Janet, Dejerine, Grasset, and Babinski, refers to abnormal suggestion only. Janet defines it as "the complete and automatic development of an idea which takes place outside the will and personal perception of the subject" [6], and Dejerine and Grasset hold a similar view. For Babinski the process is one of suggestion only when the idea conveyed is unreasonable [1]. The broadest definition is that of Bernheim, who defines it as "the process by which an idea is awakened in the mind of a subject, and accepted" [2]. This definition includes all varieties of suggestion, but does not clearly mark it off from other mental processes. The definition which is now often accepted by the English School of Psychologists is that of McDougall, given in his "Social Psychology," viz., "Suggestion is a process of communication resulting in the acceptance with conviction of the communicated proposition in the absence of logically adequate grounds for its acceptance" [12]. This definition includes both normal and abnormal suggestion, but does not make it clear whether the action is limited to processes in which there is a relationship between two persons only—a limitation which seems to be unnecessary, as it excludes auto-suggestion. McDougall could improve his definition and make it include every variety by making it read: "Suggestion is a mental process resulting in the acceptance with conviction of a proposition in the absence of logically adequate grounds for its acceptance"; and this is the definition which I put forward for the purpose of this discussion. McDougall classifies suggestion amongst his general innate tendencies as a pseudo-instinct [13], and I think it would be profitable to discuss whether it is necessary to maintain this view or whether the process of suggestion cannot be explained in some other way.

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[1] Read before the British Psychological Society (Medical Section), October 29, 1919.

We have then to explain why it is that we accept with conviction and act upon propositions made or occurring to us without any adequately logical grounds for so doing.

If there are logical grounds for accepting the proposition, the idea is generally called *persuasion*, but it is difficult to separate this from suggestion, and it seems better to include it—at any rate when used in psychotherapy as a form of normal suggestion, for there are often no logical grounds for accepting the proposition, but only logical grounds on the part of the physician for persuading the patient to accept it; moreover, to obtain conviction, affective processes must come into play, for the way of saying a thing is more important than what is said, which is expressed in the statement: "Manner is more important than matter."

There can be no doubt that *suggestibility* is the chief factor in the process of suggestion, and that the process is a subjective one; we have learnt as the result of psycho-analytical investigation that this state is not a passive state of receptivity, and that the mind cannot be compared to a vacant seat waiting for someone to fill it, as was originally held, but that it is the result of active mental processes going on in the mind of the subject, and particularly of affective processes.

Ernest Jones has called attention to the distinction between verbal suggestion on the one hand, and affective suggestion on the other [7], and maintains that the latter is the more fundamental, and is the necessary basis for the former, which view accords with Bleuler's statement, quoted by Jones, "Suggestion is an affective process." [8]. This view seems to be by no means generally accepted, but a consideration of the facts with which we are familiar concerning suggestibility compels us to admit its truth, and an examination of those facts shows more clearly the general nature of the whole process of suggestion.

§ 2.—Varieties of Suggestibility.

The chief facts are that: (*a*) suggestibility varies in different persons irrespective of the nature of the suggestion, and of the suggestor; (*b*) suggestibility varies in the same person at different times and under different conditions; (*c*) suggestibility may have reference to a particular system of ideas only; (*d*) a person may be suggestible towards one person and not towards another. I call these four distinct states of suggestibility: (*a*) individual; (*b*) conditional; (*c*) specific; (*d*) personal.

(*a*) *Individual suggestibility.*—The fact that suggestibility varies in different persons irrespective of the nature of the suggestion makes it important in psycho-therapy to be able to recognize what other characteristics are associated with exaggerated suggestibility. It is exaggerated in the child and diminished in old age: it is exaggerated in those whose egoistic instinctive tendencies are excessively developed and who make little attempt at self-control and so act on impulse, the class of persons originally described as having a sanguine temperament. This class corresponds to the "extrovert" of Jung, the "motor" type of Baldwin, the "objective" type of Bain, and the "tough-minded" of James. Suggestibility is also exaggerated in crowds, whose other characteristics are impulsiveness and incapacity to reason, with absence of judgment and of the critical spirit. Le Bon points out that "the decisions affecting matters of general interest come to by an assembly of men of distinction, but specialists in different walks of life, are not sensibly superior to the decisions that would be adopted by a gathering of imbeciles" [11].

I think also that suggestibility is more marked in those who live in the south and warm climates than in those who live in the north and cold climates, and that those whose associations of ideas take place by contiguity are more suggestible than those who associate by similarity.

It is less marked in those who hold strong principles and ideals, in methodical thinkers, whose critical powers have been well developed, and in those with the so-called "bilious" temperament, who correspond to the "introvert," the "sensory" type, the "subjective" type, and the "tender-minded."

Suggestibility is very much exaggerated in the patient with "conversion hysteria," and this has led Babinski to enunciate his conception that hysteria is due to suggestion. This conception has been accepted by many neurologists in this country, who have little knowledge of the mental processes at work in the process of suggestion and use the term in a very limited sense. When we recognize suggestion as an affective process, then we can agree with Babinski that hysterical symptoms are produced by suggestion, but we shall not be able to accept his view that hysteria be limited to the symptoms of "conversion hysteria." I therefore think it is unfortunate that Rivers should have proposed the use of the term "suggestion neurosis" as a substitute for "conversion hysteria" in his paper, "War Neurosis and Military Training" [16]. Moreover, so long as the present confusion exists in the meaning of the term suggestion the less we use it the better.

Investigations which I have been carrying out during the past year on the "psycho-galvanic reflex" point to the fact that exaggerated suggestibility is always associated with a low "emotive response," and Dr. Snowden informs me that similar results have been obtained by Dr. Golla and himself at the Maudsley Hospital. If it could be shown that the converse is true, that a low emotive response is always associated with exaggerated suggestibility, then we should have a means of measuring suggestibility. More work needs to be done on this subject, for apart from the fact that we are not yet decided as to the physiological nature of the reflex, it seems certain from the psychological standpoint that two factors must be taken into account, the liberation of emotion on the one hand, and the stimulation of "contrary" forces on the other. I use the term "contrary" forces in order to avoid the words "repressing," "inhibiting," and "controlling." I mean the forces which are brought into action by stimulation of mental processes on a higher level: they are "contrary" as applied to suggestion, and act in opposition to the instinctive processes on the perceptual level. Physiologically they are the forces set free by stimulation of the cerebral cortex; following Rivers in the symposium on "Instinct and the Unconscious," I might perhaps use Head's term and call them "epicritic." It is possible that the psychogalvanic reflex may be an indication of the strength of the "contrary" or "epicritic" forces stimulated by the liberated emotion, and that it is not merely an emotive response.

From a consideration of these facts we can explain individual suggestibility as being due to the varying degree in which the egoistic instinctive tendencies are developed and the manner in which the sentiments have become organized to form ideals and act as contrary forces.

(b) *Conditional suggestibility.*—The variation of suggestibility in the same person at different times and under different conditions seems to depend upon the affective state in which the person happens to be, and the relation of the suggested idea to that state. I have found that even patients who generally go into a deep state of hypnosis are resistant to hypnosis on one day and will go off into their usual state on the next. Suggestibility is increased during hypnosis, fatigue, illness, and prolonged emotional states, and by the effect of alcohol and certain drugs, conditions in which the "contrary" forces are weakened. A wife, for example, recognizes that a husband is more suggestible after a good dinner and chooses this time to get her propositions accepted.

(c) *Specific suggestibility.*—That suggestibility may refer to a particular system of ideas only is also an important fact pointing to the affective nature of the process. A person is specially suggestible to ideas that are pleasing to him and which satisfy his egoistic instinctive tendencies; according as those specific tendencies are developed so does his suggestibility vary towards ideas which evoke them, and we recognize that in the same family these tendencies are developed in each of the children in varying degree.

With the growth of sentiments and the appearance of complexes and interests, both actual and dispositional, as the result of experience, so does the suggestibility vary according as the suggestions harmonize with the affective states induced by them. Thus each person has his own particular sphere of suggestibility, and even under hypnosis the suggestibility is not the same for all suggestions. This is more clearly explained by a quotation from a paper by Ernest Jones on "Psycho-analysis and Education": "A desire that arises in a person's mind for the first time is not likely to be very effective or significant unless it becomes attached to others that are already present; in other words, a motive appeals more readily to him if it is linked, by resemblance, to earlier ones already operative in him." [9].

(*d*) *Personal suggestibility.*—Suggestibility towards one person and not towards another depends on the affective processes operating between the two persons. Sympathy, respect and confidence between the subject and the suggestor favour suggestibility. I have found it more difficult to hypnotize the patient of a colleague than one of my own.

Anything which tends to increase the authority and prestige, either personal or acquired, of the suggestor, increases suggestibility in the subject; thus a parent can produce suggestibility in a child, a teacher in a pupil, and a physician in a patient.

McDougall has pointed out that the personality comes into play in virtue of the relative strengths of the two instincts of "self-assertion" and "subjection." "Personal contact with any of our fellows seems regularly to bring one or other, or both, of these instincts into play" [14], so that suggestibility is only evoked in us by persons who make upon us an impression of superiority of any kind in the particular situation of the moment. McDougall relies on the strength of these two instincts to explain individual suggestibility: but although they are important—especially the instinct of self-assertion in virtue of the part it plays in the organization of the sentiments on a higher level—other instincts play an equally important part. It is probable that prestige owes its power to the complex emotions of admiration and awe, and often of gratitude and reverence, which are evoked by the instincts of curiosity, subjection, self-preservation, and the parental instinct. Whether we accept Freud's view, that the above tendencies are but sublimations of the sexual instinct, or not, we have got to admit the influence of the sexual instinct, for we know that a sentiment of love or affection favours the sympathetic induction of emotion between two persons. According to Ferenczi: "Everything points to the conclusion that an unconscious sexual element is at the basis of every sympathetic emotion, and that when two people meet, whether of the same or the opposite sex, the unconscious always makes an effort towards transference" [3] and that this transference has its deepest roots in the repressed parental complexes. It is also significant that in the two classes of homo-sexuals, described by Ferenczi [4], the "subject" and "object homo-erotics," the "subject-homo-erotic" has an increased suggestibility, and although my experience of these cases is small, it is that the "object-homo-erotic" is not at all amenable to suggestion.

It is outside the scope of this discussion to go further into the psycho-analytical standpoint, and Ernest Jones has already set forth the Freudian point of view in his paper on the "Action of Suggestion in Psychotherapy" [10] to the effect that "suggestion" is a special variety of transference, namely, that concerned with the transference of positive affects to the physician, and that suggestibility takes its root in the masochistic component of the sexual instinct. It is impossible for anyone to discover the truth of Freud's theories without psycho-analytical investigation; my own position is that I accept the greater part of Freud's theories in so far as the fate of the "pleasure-principle" is concerned, and his theory of sexual development and sublimation has been confirmed by my experience in psycho-analysis, but I think that the development and sensitivity of the "reality principle" is of much more importance than Freud seems to allow, and that Janet is right in so far as he emphasizes its significance.

A consideration then of facts shows that all four forms of suggestibility, which I have described as individual, conditional, specific, and personal, come into play in the process of suggestion,. and that these are affective states evoked by the stimulation of different instinctive tendencies, sentiments, interests, and complexes.

§ 3.—Classification of the Responses to Suggestion.

Any explanation of suggestion must explain not only why suggestions are accepted, but also the circumstances under which they are refused, and even strongly opposed. If we take the results of attempts at suggestion in everyday life we can classify them into three groups:—

(*a*) Positive response when the suggestion is accepted.
(*b*) Negative response when the suggestion is opposed.
(*c*) Neutral response when the suggestion is refused.

These results depend on the relationship of the suggested idea to the different states of suggestibility already described.

(*a*) *Positive response* may be immediate or delayed; the immediate response gives us the most typical example of the process of suggestion, for in the delayed response there are also at work other factors which I shall describe under "neutral response."

Most writers are inclined to the view that if a suggestion is accepted it is due to the inhibition of other ideas opposing its acceptance, and that realization of the idea takes place simply by ideo-motor action. This view involves the difficulty that it depends on the meaning of inhibition, and that we do not understand the nature of ideo-motor action.

Hart in his paper, "Methods of Psychotherapy" [5], attaches great importance to inhibition, but recognizes that it is brought about by affective processes; for him "suggestion" is "complex thinking," by which he means thinking due to the action of a complex, using the term complex in a very wide sense. He speaks of the capacity of suggestion "for inhibiting conflicting ideas and tendencies." This seems to be an inadmissible use of the word "inhibition"; the verb "to inhibit" is an active and transitive verb, and the word "inhibition" thus conveys the idea of an active process. If I go downstairs, it might be true to say that by so doing I was inhibited from going upstairs, but it would hardly be a correct usage of the word; the idea of going up would never arise and would not require inhibition. Suggestion has no capacity for inhibiting ideas, but, if we speak in terms of inhibition, is rather the consequence of the inhibition of inhibiting forces normally involved in volition.

Moreover, the term "complex thinking" lays too much stress on the cognitive aspect of the process of suggestion, and though this is the first stage in the process, more than this seems to be involved; for example, if, during a railway strike, I merely thought of an engine as the means of transport for getting me to town, nothing further would result, but if forces were aroused in me sufficiently strong to make me "tip" the engine-driver, then I should be acting under the influence of suggestion. No other ideas would arise if the response was immediate, and no ideas would be inhibited.

The term "ideo-motor action" is a relic of the old psychology of ideas; for example, for Hegel, "an idea is a force, and is only inactive in so far as it is held in check by other ideas" [21]. If the process of ideo-motor action be analysed, it is found that the action depends entirely on the affective forces aroused by the idea, and that no idea will realize itself unless it is reinforced by some affective force. Ideo-motor action is thus equivalent to the expression of emotion. We know that emotion is expressed normally through the autonomic nervous system, and, when excessive, through the central nervous system. It is evident that persons, whose instinctive tendencies are highly developed, and whose sentiments have not been well organized to act as "contrary forces," will realize their ideas in action through the central nervous system without opposition, and I have shown elsewhere that this may be an explanation why a patient with conversion hysteria develops symptoms attributable to the central nervous system, and a patient with anxiety hysteria develops symptoms attributable to the autonomic nervous system.

It follows from what I have already said that I here maintain the view that an idea is accepted because it harmonizes with some pre-formed interest, sentiment, or complex, that the affective forces involved give it the necessary reinforcing power to realize itself in opposition to all "contrary forces," and that it is these affective forces which produce conviction. Any condition which tends to weaken the "contrary forces" on the one hand, or strengthen the compatible affective forces on the other, favours the process of suggestion, and we have noted that the conditions which cause "conditional suggestibility" are those which weaken the volitional forces, and that individual suggestibility is exaggerated in those who are endowed with strong emotional tendencies and have a poor development of self-control.

McDougall has shown that it is the organization and strength of the self-regarding sentiment in relation to the other sentiments which determines our line of action and constitutes our self-control; as this higher control, though it relies for its strength on the self-regarding sentiment, involves the formation of ideals, and is, perhaps, influenced by the herd instinct, I have called it elsewhere the "social ideal self" as a contrast to the "individual self" [15]. Individual suggestibility then depends very largely on the strength of the social ideal self; and the weaker the social ideal self, the greater the number of complexes that remain unsublimated, and the greater are the states of specific and personal suggestibility.

Wilfred Trotter has pointed out how one form of suggestion, "herd suggestion," is due to the action of herd instinct, and that "anything which dissociates a suggestion from the herd will tend to ensure such a suggestion being rejected" [20]. It is owing to the influence of the herd instinct that we may accept propositions in regard to religion, politics, and education. Such beliefs are non-rational, and are accepted by us as the result of accumulated suggestions.

The exaggerated suggestibility of children, occurring when they have reached the age of paying attention, which is in its turn dependent on the interest aroused, is due to the evocation of the instinct of submission, the weakness of the social ideal self, and the absence of resistance complexes. For opposite reasons old people are less suggestible.

(*a*) *Negative response* is the response obtained when not only is the suggested idea incompatible with pre-formed sentiments and interests, but it arouses contrary emotions and sentiments. This is the process which is called "contra-suggestion." The mechanism is the same as for the positive response, but an opposing set of forces are set in action with the production of a state of "negativism"—a state which is the direct counterpart to suggestibility. This state, like suggestibility, may have individual, conditional, specific, or personal tendencies. It seems to be a form of over-determination due to the presence of antagonistic complexes, which more than counterbalance the forces of a weak social ideal self.

Like suggestibility, negativism may be exaggerated, and become pathological; it is most marked in dementia præcox.

Some people appear to adopt "negativism" as a habit; such are the people we call "cranks." I look upon the action of these people as being that of over-determination, owing to the formation of complexes associated with painful experiences in the past.

In psychotherapy, when we have established an atmosphere of cure, negativism signifies an unconscious resistance to recovery, and when exaggerated it must make us suspect dementia præcox, or malingering if it seems likely that the resistance is a conscious one.

(*c*) *Neutral response.*—It is hard to draw the line between the lower forms of volition and suggestion. If the idea is incompatible with the social ideal self and the social ideal self is strong, then the process is one of volition and we get a neutral response; this is what happens in those who hold strong principles and ideals. If the social ideal is too weak, and the affective forces aroused are strong, the idea is accepted and the process is one of suggestion.

If the idea has not made sufficient impression, we get a neutral response, and this is due to the fact that there are no pre-formed interests or complexes to which it can attach itself: in this case the suggestion is ignored. This is seen most markedly in certain imbeciles. The suggestion may need repetition to give it the necessary amount of prestige for acceptance, a fact which is taken into consideration as a basis for all advertisements. The suggestion may be incompatible with such interests and complexes as exist, and the forces involved simply neutralize each other, which is one of the reasons for the fact that the suggestions of the younger generation are not easily accepted by the elder.

A neutral response may also be the result of a conflict of motives due to the incompatibility of the interests aroused, with the production of a state of doubt, which is seen in an exaggerated form in cases of anxiety hysteria: in such cases the suggestion may be accepted after deliberation either to relieve tension, or when a decision is brought about by the reinforcement of one side of the conflict by further affective forces: or the conflict may be forgotten and only at some later period will one side of the conflict materialize by the stimulation of affective forces which harmonize with it. A neutral response will also occur in cases of "dementia."

§ 4.—Abnormal Suggestion.

The process in abnormal suggestion is the same as in normal suggestion, and depends on the factors already discussed, which increase the various states of suggestibility. The difference is only one of degree, and in abnormal suggestion the affective forces are stronger, and the "contrary forces" are weaker, so that the person is less or not at all aware of their action and has little or no control over them. This is best seen in persons suffering from hysteria; when their affective states are dominated by the desire to escape from some irksome duty or future danger, to astonish, attract attention or sympathy, any idea harmonizing with this state becomes reinforced and realizes itself.

We also know that hysterical patients can temporarily put aside their hysteria by a change in their affective state when the situation requires particular concentration on some interesting function or amusement. I think that the disappearance of hysterical symptoms as if by magic in the presence of danger and the sudden recoveries reported in the newspapers are explained by the fact that one affective state is substituted for another by the re-direction of attention under the influence of surprise. I regard hypnosis, in accordance with Bernheim's view, as an exaggerated form of suggestion. I cannot accept Rivers's statement in "War Neurosis and Military Training," that, "In the hypnotic state the individual responds immediately and without question or hesitation, not merely to the command of his hypnotizer, but even to a desire or impulse of the hypnotizer's mind which is not expressed by speech or obvious gesture" [17]. It implies the presence of some mysterious force, an idea which we are only just beginning to uproot from the popular mind, and my own experience, and I think that of all other observers of recent times, is entirely opposed to it.

The explanation of suggestion I have given seems to make it incorrect to classify suggestion as an innate tendency. We have seen that there is no one single state which we can call suggestibility, but that there are several states of suggestibility, and that these are induced by the stimulation of different instinctive tendencies, sentiments, interests, and complexes.

We have seen that a suggestion is accepted because it harmonizes with these states, that the affective forces aroused give it the necessary reinforcing power to realize itself, and that it is these affective forces which produce conviction. We have now to consider briefly how we can apply this conception to suggestion as a method of treatment.

§ 5.—SUGGESTION AS A METHOD OF TREATMENT.

The object to be attained in treatment by suggestion is to produce a condition of mind in the patient which will set in action the right affective forces for the induction of those states of suggestibility which will harmonize with and reinforce the ideas to be suggested and so get them accepted with conviction.

The first step in the process is for the physician to induce a state of personal suggestibility in the patient, and this he does by arousing in him the necessary instinctive tendencies, showing him sympathy, and impressing him with a knowledge of and interest in his condition, so that the patient has respect for and confidence in the physician. In neurasthenic hospitals, where an atmosphere of cure is present, this state is induced in him on admission by the patients, who have been already relieved of their symptoms, for success is the greatest creator of prestige.

The physician then proceeds according to the type of patient he has to deal with, and to the amount of personal suggestibility already induced; if the states of individual and conditional suggestibility are exaggerated, then it will not matter what form the suggestion takes; but if there is only particular suggestibility, then it is necessary, if possible, to find out its nature by therapeutic conversations and superficial analysis, and so to arrange the suggestions as to be compatible with it.

In one form of abnormal suggestion advantage is taken of the effects of some emotional reaction to alter the affective state. An emotion frequently used is that of surprise, which "tends to free the mind from what before occupied it, and to increase the intensity of every emotion with which it blends, or by which it is rapidly followed" [18]. If the affective state be that dominated by fear, it may be counterbalanced by inducing a state of anger, for "the emotions of fear and anger tend to exclude one another from simultaneous activity" [19]. I think also that painful electricity, the use of which has done considerable harm, and isolation, depend largely for their results on the change of affective states induced by them.

Other methods depend on the fact that the suggestion will not be accepted with conviction unless it is associated with some specific treatment to account for the cure. This form of suggestion is "indirect suggestion," and is often used quite unconsciously by the medical profession. It is used either by insinuation with the help of massage, drugs, electricity, or by deliberate deception—for example, the use of water without morphia as an injection and the use of bread pills for functional vomiting. Hypnosis is in most cases unnecessary, and although at one time I used it very extensively, I now only use it to clear up an extensive amnesia.

Of the methods of "suggestion treatment," there is no question that the method of normal suggestion by explanation and appeals to feelings is the best, as the patient then realizes that he himself is responsible for the removal of symptoms, and he will know what to do in case of a relapse. In the other methods he relies entirely on the physician, does not understand his condition, and is much more likely to relapse.

But, in any case, it must be noted that the patient relies on the explanation given to him, and that the real cause of the condition may never have been discovered. Treatment by suggestion does not, therefore, conform to our ideal method of treatment, and is not here advocated as such, but it is very useful in practice as a method of removing symptoms in certain cases.

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LETHARGIC ENCEPHALITIS; ITS SEQUELÆ AND MORBID ANATOMY.

BY E. FARQUHAR BUZZARD, M.D., F.R.C.P.,

AND

J. G. GREENFIELD, M.D., B.Sc.

IN the spring of 1918 attention was drawn by Dr. Wilfred Harris and Professor A. J. Hall to the presence of an epidemic disease which has since become generally known as lethargic encephalitis. The disease was prevalent with fluctuating severity until the summer of 1919 and was more or less associated and coincident with a prolonged and severe epidemic of influenza, which also presented marked fluctuations. Many cases of encephalitis were, in their early stages, regarded as cases of influenza, and both diseases were characterized pathologically by the hæmorrhagic nature of their inflammatory lesions. Whether the relationship between influenza and lethargic encephalitis is more intimate than we are at present aware of, or whether their association was purely accidental, are questions which cannot yet be answered.

In the early days of the epidemic lethargic encephalitis was supposed to be characterized by asthenia, lethargy and disorders of ocular movements, but our outlook was rapidly broadened by experience, so that the name now embraces a much larger group of symptoms, which varies with the incidence of the inflammatory process on different parts of the central nervous system.

The following pages contain a recapitulation of the contents of two papers[1] already published, to which have been added the results of some more recent observations and a description of the morbid anatomy of the disease.

It is our purpose here to draw attention to the great variety of symptoms and physical signs which may result from an attack of encephalitis and to the interesting late phenomena which are in many cases a legacy of the disease. That the symptoms of an inflammation of the brain should vary in almost every case is not a matter of surprise; on the contrary, it would be astonishing if inflammation of an organ, of which the functions are so numerous, did not give rise to a versatile symptomatology.

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[1] (1) "An Address on Lethargic Encephalitis," by E. Farquhar Buzzard, *Lancet*, December 21, 1918. (2) "Encephalitis Lethargica," by E. Farquhar Buzzard, *Proceedings of the Royal Society of Medicine*, August, 1919, vol. xii, No. 9.

The diagnosis, therefore, of lethargic encephalitis can never depend on the presence or absence of any symptom or group of symptoms. It must be determined by a consideration of the onset and course of the disease, and by the elimination of other pathological conditions which may produce similar symptoms and physical signs.

We hesitate to make an attempt to describe different types of the disease dependent on the anatomical incidence of the inflammatory process, because the definition is rarely so exact as to deserve it, but we may point to three groups of cases with characteristics sufficiently distinct to merit consideration.

(1) Cases characterized by hemiplegia, hemianæsthesia, hemianopia, &c.

(2) Cases characterized by symptoms resembling those of paralysis agitans; the basal ganglia group.

(3) Cases characterized by disturbances of function of the cranial nerves.

These three groups correspond to different anatomical levels of the brain, and suggest the chief incidence of the inflammation in each, but both clinical and pathological observations show that the disease is always more widespread than might be suspected from the most prominent symptoms.

The first case to be described affords a good illustration of the disease in its acute and fatal form when the chief incidence of the inflammation falls upon the cranial nerve nuclei. There is plenty of evidence, however, to show that other parts of the brain were affected, especially in the early stages of the disease. The lethargy, which is so characteristic of some cases, may possibly be attributed to a condition of hydrocephalus induced by inflammation and œdema in the region of the corpora quadrigemina interfering with the circulation of the cerebrospinal fluid through the aqueduct of Sylvius.

Case 1.—A married lady, aged 27, in the last few weeks of her second pregnancy complained on January 13, 1919, of diplopia and a strange feeling in her head. During the next two days she went about as usual, but appeared at times to be confused, drowsy and unable to remember the object of her shopping errands. On January 16 she had an easy and uncomplicated confinement. On January 17 her temperature gradually rose to 104° F., headache was severe and there was increasing drowsiness and disorientation. On examination she presented partial bilateral ptosis, weakness of the left inferior rectus muscle, an expressionless face, slight tremor of the tongue and hands, with normal tendon jerks and doubtful plantar responses. The next day she was more drowsy and asleep all the time unless she was roused. The ptosis was more marked and the temperature remained between 103° F. and 104° F. The optic discs were slightly congested. A papular rash had appeared over a large part of the surface, particularly over the forearms, buttocks and anterior aspects of the legs. A lumbar puncture obtained cerebrospinal fluid in which no abnormal cells could be detected. On January 20 the patient was much worse. She lay in a muttering delirium, cyanosed, picking at the bedclothes, with a pulse of 140, mucous râles in the chest, rapid respiration and an intense general morbiliform rash. There was now complete ptosis and palsy of all ocular movements. Swallowing had become impossible and the patient resented light thrown into her eyes. Death seemed imminent, but during the next forty-eight hours there was a remarkable rally. The temperature fell, the rash faded, pulse and respiration improved, but the ocular palsies and the dysphagia remained. At this time involuntary local spasmodic movements were very noticeable in the limbs. On January 23 the temperature was below normal and the patient had spoken a few words quite rationally and asked after her baby. Swallowing was again possible, but the eye movements were no better. The same night, however, the temperature shot up to 104° F., the rash reappeared in a still more intense form, and the patient went rapidly downhill, dying on January 25.

This case was remarkable for the pyrexia, for the rash which challenged comparison with a very severe measles eruption and for the occurrence of a fatal relapse, falsifying the apparently justifiable hopes of recovery which were entertained two days before death.

The next two cases illustrate the rare occurrence of two members of the same household contracting the disease. In both patients, a mother and her son, the symptoms pointed to an affection of the hemispheres, and signs attributable to the involvement of cranial nerve nuclei were absent.

Case 2.—The son, aged 19, came home from a theatre on March 28, 1919, suffering from headache and feeling feverish. The next day his temperature rose and on March 30 a rash appeared, giving rise to a suspicion of scarlet fever. The following day headache was severe and the patient had a sudden generalized convulsive attack which left him in a semi-comatose condition. When seen on April 1, he lay half unconscious with closed eyes and displaying a marked resentment to all examination or disturbance. The right arm was obviously paralysed, the abdominal reflexes were sluggish and the knee-jerks difficult to obtain. A lumbar puncture released fluid at increased pressure The only abnormality detected on complete examination was an increase in the glucose content. The patient recovered consciousness a few hours later and was found to have difficulty in speaking and to have weakness of the right side of the face and of the right arm and hand. From that time recovery was progressive and uninterrupted, but at the end of a fortnight the weakness of the face and grasp was still perceptible.

Case 3.—On April 14 the mother, aged 54, who had been much with her son, began to feel as if her tongue and throat were swollen and complained of headache. The next morning headache was severe, the temperature was 101° F., and the patient displayed an intense morbiliform rash all over the chest, abdomen and arms. Photophobia and vomiting added to her discomfort. The cerebrospinal fluid was at high pressure and resembled the specimen obtained from the patient's son except for a slight increase in the percentage of chlorides. The patient suffered from the headache and vomiting for two days and during the same period exhibited weakness of the left side of the the face and of the right arm, but her recovery was more rapid than that of her son.

During the last two years a number of cases of encephalitis have been observed which form a marked contrast to the severe type just described, and many of which have never been considered or have never considered themselves as seriously ill. This group is characterized by the insidious onset of slight lethargy, an inclination to fall asleep whenever they sit down to rest or read, or a tendency to forget the small things of everyday life, and sometimes by an alteration of temperament. The patient may complain of diplopia which lasts for a few days to a few weeks, or of a general stiffness or slowness in his movements. He may complain that although he is always dropping off to sleep in the daytime his night's sleep is disturbed by restlessness, by mild cramps or pains in his limbs, so that he wakes every hour or two. Headache may never be complained of and fever may be conspicuous by its absence.

Case 4.—A recently married lady of 27 was seen in consultation because she was always dropping off to sleep and complained of double vision. She had a slight feeling of nausea and said her head felt "buzzy." She stated that she had gone to the butcher's and left her coupon as well as her meat. On examination the left palpebral fissure was wider than the right and diplopia was obtained on directing the patient's eyes to the left. She had no other physical signs and she made a complete recovery in the course of a fortnight or three weeks, but the precaution was taken of sending her to bed for a rest. Her symptoms were almost identical with those of Case 1 in the first few days of her illness, and it was impossible to say whether the more serious and fatal sequelæ might not supervene.

Case 5.—In February, 1919, a man aged 59 stated that in December, 1918, as he was walking to catch his morning train to the City, he noticed "everything looking double," and that in the course of a week he became stiff all over, "making me feel like an automatic figure in my movements." He had no headache but felt very sleepy and could not keep awake when reading. His appearance suggested the diagnosis of paralysis agitans, judging by his mask-like face, the gait, and the way in which he held his arms and hands. He complained of slight twitches at times in his hands and particularly of the slowness with which he dressed and undressed. The diplopia had cleared up and he was improving in every way. When seen again in April he was much better and could then write freely and dress himself in normal time.

Case 6.—On February 11, 1918, a lady aged 53 complained for a fortnight of slight headache and sleepiness. On January 31 she had developed diplopia, increased drowsiness and mental disorientation with a slight degree of ptosis. She was restless and unable to concentrate her attention. She presented slight weakness of the right side of the face and the right hand tended to assume the paralysis agitans position with occasional twitching of the fingers.

There were no other physical signs, but the temperature was apt to reach 100° F. on some days. This lady's progress towards recovery has been very slow, especially in regard to her mental condition. She is still depressed, easily exhausted and unable to keep her interest or attention fixed for any length of time.

Case 7.—A lady aged 46, after feeling seedy for two or three weeks, was seized on March 30, 1919, with some headache and vomiting and pyrexia which lasted for several days. Photophobia and bouts of drowsiness with a milder degree of headache persisted after the fall of her temperature. On examination she presented a slight degree of ptosis on the right side, absence of all abdominal reflexes and sluggish tendon jerks. She made a good but slow recovery.

Case 8.—A gentleman, aged 63, in March, 1919, complained that a week before the consultation he was seized with diplopia while playing billiards. This was followed by headache and general restlessness, a little cramp in the legs and paræsthesiæ in both hands. He presented partial ptosis, more marked on the right, and weakness of all ocular muscles, especially in regard to the internal and vertical movements. The right pupil reacted sluggishly to light. The knee and ankle jerks were difficult to obtain, and the right plantar reflex was indefinite in type. In spite of the comparative severity of his symptoms this patient made a rapid recovery in the course of a fortnight, during which time he was kept in bed.

Case 9.—On June 6, 1919, a lady, aged 42, stated that two months previously she had been suddenly seized with diplopia, drowsiness, general loss of power, loss of memory and loss of control over her emotions. She stated that she felt as if she was in a dream and that, whereas she had always been lively and bright, she was now quite altered in temperament and only wished to go to sleep. She had not suffered from headache or vomiting, and as far as she knew had had no rise of temperature. On examination her pupils were found to be sluggish, there was left-sided ptosis and paresis of the left internal rectus muscle. Her face was expressionless and her movements generally feeble, but the reflexes were normal. It may be noted that she had never been laid up in bed, and that she had been medically advised to go about as much as possible and to seek lively company.

These cases of mild encephalitis could be multiplied, but a sufficient number have been described to indicate their general symptomatology and physical signs and to support the view that they must have been very numerous during the last two years. The physical signs have been generally trivial and would easily have escaped notice with any but careful examination. The histories obtained from the patients and the account of their symptoms have been important factors in the diagnosis, which has been confirmed by the general tendency towards recovery in the course of a few weeks or a few months. One can hardly doubt that early diagnosis is a matter of great importance in these cases, and that patients who are suffering from an inflammation of the brain should be prevented from carrying on their normal activities even though they are not troubled with headache, vomiting or pyrexia.

Attention must now be drawn to another very interesting and serious aspect of the more severe cases of encephalitis who recover from the acute stage of the disease, but who are overtaken by more or less disabling sequelæ at varying intervals of time. We refer to the late development of involuntary movements affecting the limbs, jaw or tongue. Some of these patients have passed through an acute illness associated with severe headache, vomiting, fever and other cerebral symptoms which have given rise to the diagnosis of influenza, meningitis, &c. Some of them have displayed involuntary movements during the acute disease, the abnormal activities disappearing in the course of a long convalescence. It would be difficult to describe accurately the character of these movements; some have been irregular and choreiform, others more rhythmical and limited in their distribution. One of the patients had movements confined to the left foot which she aptly nicknamed her "joggles." Speaking generally the movements are in abeyance while the parts concerned are in voluntary use and are most obvious when the patient is resting. On the other hand, all these movements cease during sleep and gradually subside in the process of going to sleep. The movements do not interfere with voluntary action and are only a source of complaint in that they disturb the patient's peacefulness while at rest.

Case 10.—W. H., aged 28. A fireman on the Great Eastern Railway. Family and previous history good in all respects. He was taken ill on June 4, 1918, and went to bed on June 6 with headache, general malaise and sleeplessness. The right side of the face became paralysed, there was difficulty in mastication and fluids regurgitated through his nose. The latter symptom only lasted about ten days, but by June 27 he displayed tremor of his right hand in shaving and writing and his legs appeared to be weak. His reflexes at that time were normal. During the next six months he made little or no progress towards recovery and by December his legs were showing involuntary movements which spread to the left arm early in 1919. When admitted into the National Hospital in April of this year he displayed constant movements of both shoulders more marked on the left side. The movement of the left arm may be best described as "trouser hitching" and included contractions of the deltoid, latissimus dorsi, trapezius and biceps muscles. There were also forced movements of the head chiefly carried out by the deep muscles of the neck. In the legs contractions of several groups of muscles were obvious while he lay in bed, but these were suspended during walking or other voluntary movements and during sleep. The pupils were dilated and unequal, the left being larger and less active to light than the right. The right side of the face was weak in voluntary action, but at rest showed an increase of tone and clonic spasms.

The strength of the limbs appeared to be about normal, but when the arms were outstretched there appeared coarse movements at the shoulder which were increased by fatigue. The arm movements showed some dysmetria and dysdiadochokinesia. The reflexes were normal in all respects.

During the last three months the patient has shown marked improvement. His blood and cerebrospinal fluid have been examined with negative results.

Case 11.—J. W., aged 44. A packer. Seen for the first time on June 1, 1919, at St. Thomas's Hospital, when he stated that six weeks previously he had noticed diplopia, mental confusion and tremor of his right arm and right leg. He presented a typical paralysis agitans appearance in posture and facies. The reflexes were normal. A month later he complained of increased tremor in the right hand and dragging of the right foot and constant twitching of the muscles of the right thigh. In July and August he was improving. In November he was walking more freely but displayed coarse involuntary movements of the right hand. In January, 1919, there were continuous involuntary movements of the jaw and tongue which were suspended during talking and eating. During the last six months these have gradually decreased and are now hardly noticeable. He expresses himself as very much better in all respects, but his resemblance to a case of Parkinson's disease is still obvious.

Case 12.—A. M. P., a married woman, aged 35. Sent to the National Hospital by Dr. Davidson, who kindly supplied the following note dated November 20, 1919: "Illness started in February, 1919 (when she was seven months pregnant), with acute pain down the left arm. Two or three days later I was sent for and found her sitting in a chair, twitching all over, muttering to herself and only semi-conscious. The movements were choreic, and I thought at first it was a bad attack of chorea gravidarum. I got her into the local infirmary, where she lay unconscious for several days and miscarried. She was discharged from the infirmary about a fortnight ago, but although her mind is clear she is scarcely able to walk and is on the twitch all day long."

On examination she showed constant involuntary movement of internal rotation of the left shoulder with flexion of the left elbow. The trapezius and pectoral muscles also took part in this movement. The right arm was similarly affected but to a less degree. Tendon-jerks exaggerated. Left plantar response was extensor, right flexor. No sensory disturbance. Slight diplopia has been present but has now cleared up.

Case 13.—L. F., a single woman, aged 28. Suffered from chorea as a child. Seen on April 4, 1919, at the National Hospital, when she gave the following history:—

A year ago she went to the doctor with a sore throat and headache and felt faint on her return home, when she lost power in her left arm and leg. This gradually recovered, but left her with involuntary movements in her left leg and some tremor and unsteadiness in her left arm and hand.

On examination the right pupil was larger than the left. The left abdominal reflex was absent, the left knee-jerk more brisk than the right and the left plantar reflex indefinitely extensor in type. The left foot was in a state of constant movement while sitting, but quite steady when she was walking or standing. She has an old mitral lesion and it is possible that her condition is due to an embolic lesion.

Case 14.—A man, aged 52, with a history of good health, was seriously ill for six weeks in May, 1918, with what was called "influenza." During a part of this time he was unconscious and he had never felt strong since his recovery. About September, 1918, he noticed involuntary twitching of the right toe which spread until it affected the greater part of the right leg and right shoulder.

When seen at the National Hospital in December, 1918, he was found to be well nourished and of normal intelligence. His arteries were somewhat thickened and tortuous, but the heart and other organs were healthy. The Wassermann reaction of the blood and cerebrospinal fluid was normal. Nothing abnormal was detected in the function of the cranial nerves.

When standing the patient displayed involuntary movements of the right upper limb produced by contractions in the right trapezius, rhomboids, spinati and deltoid. The movements recurred at intervals of one to two seconds and the right arm was thrown behind the trunk and slightly elevated with each spasm.

The left erector spinæ was sometimes contracted at the same time and the right abdominal muscles in such a way that there was an irregular rotatory movement of the abdominal wall and umbilicus. Clonic contractions occurred in the muscles of both buttocks and in most of the muscles of the right thigh and leg when the patient was at rest. All voluntary movements could be performed with good power and the involuntary movements could be controlled by voluntary effort, at any rate for a time. There was no disturbance of sensibility and all reflexes were normal. The movement in the right arm bore a strong family resemblance to that seen in Case 10.

Case 15.—This patient, a young man who was seen by the courtesy of Dr. Head in November, 1919, was then 28 years of age. He stated that he was quite well until March, 1916, when he had a serious illness which was described as influenza. During part of that illness he was unconscious and catheterization was necessary. During convalescence he was very weak on his legs and found some difficulty in articulation, and a few weeks after returning to work he developed a tremor which affected the greater part of his body and which was increased by emotion, fatigue or any sustained effort. This tremor has been gradually disappearing and becoming more limited. On examination I found him slightly lacking in facial expression, but otherwise the functions of his cranial nerves appeared to be normal. Under observation he showed an irregular rhythmic movement of his trunk, and when he was stripped and lying on his back on a couch it was possible to analyse the muscles which were concerned in the involuntary movement, especially when he was asked to raise one leg off the couch and sustain it in that position against resistance. Such an effort produced a rhythmical contraction of the oblique muscle in the left flank as a first and minimal effect, but this was quickly followed by rhythmical contractions of the left latissimus dorsi and of the left erector spinæ, a muscle which appeared to be in a state of slightly increased tone even while he was standing with his feet together. When the involuntary movements became intensified they were apt to spread to other muscles on the other side of the trunk. The tendon-jerks were normal, the plantar reflexes flexor in type, but no abdominal reflexes could be obtained.

Case 16.—A man, aged 30, was seen at the National Hospital on January 1, 1920, when he stated that in December, 1918, he was in another London hospital seriously ill with a disease diagnosed as encephalitis lethargica. He made a fairly good recovery and was working at a light job for eight months during 1919, but in December of that year there was a marked increase in the stiffness and disabilities of his left limbs so that he was obliged to give up his work. On examination he presented the appearance of paralysis agitans in regard to his facies and general posture. His articulation was rather hesitating and there was some vertical and lateral nystagmus. He described his left hand as being always cold and had noticed occasional twitches in it. All reflexes were normal.

This patient's history is recorded because he illustrates the occasional relapse of symptoms occurring months after the original illness, and the fact that this relapse is not always represented by involuntary movements but sometimes by an intensification of rigidity and paresis.

It would, of course, be impossible to provide scientific proof that each and all of these patients have suffered from lethargic encephalitis, but circumstantial evidence is strongly in favour of this hypothesis. Involuntary movements have been frequently observed during the acute stage of the disease, but the chief interest of several of the cases here described attaches to the development of movements weeks or months after convalescence has become established.

Following the common encephalitis of infancy and childhood athetosis and choreiform movements associated with some degree of hemiplegia or diplegia are occasionally met with, but so far we have not seen true athetosis as a sequel to the lethargic variety. This difference may depend on the age of the patients or upon some difference in the pathological results of the inflammatory lesions. Reference will be made later to the degenerative changes which we have found in the cerebral blood-vessels in cases of lethargic encephalitis some weeks or months after the acute illness.

In the present state of our knowledge it is difficult to correlate the occurrence of involuntary movements with any local lesion, and it is more difficult to determine whether the former are the result of some chronic irritation or whether they represent the release of some nervous activity by interference with control. The latter theory is, in our opinion, the most probable, especially in view of the fact that these movements can be temporarily controlled by the patient and generally cease when the affected part is being voluntarily employed.

So far as treatment is concerned we have seen no good results from drugs, massage or electricity, but improvement has generally taken place while the patient has been encouraged to re-educate his control over the movements, and the prognosis is favourable even when the distressing symptoms have been present for many months.

The next four cases described belong to Group I, and serve to emphasize the difficulty in diagnosis, especially in regard to the possible presence of cerebral tumour, cerebral abscess or cerebral hæmorrhage.

Case 17.—On Thursday, March 28, 1918, a lady, aged 54, noticed that her right hand was rather shaky. The next day she went away for the Easter holidays, but returned on the Sunday on account of the uncontrollable jerking of her right arm and hand, which gradually became worse and spread to the whole of the right side. When seen on April 5 there was a mixture of clonic and tonic spasm, affecting the whole of the right side, with considerable impairment of voluntary movement and more or less complete aphasia. The reflexes on the affected side were of the usual hemiplegia type, whilst those on the left side were normal. There were a few movements noticed in the left arm, but there were no cranial nerve disorders beyond the weakness of the right side of the face. There was no optic neuritis and nothing in the cardio-vascular condition of the patient to explain the symptoms.

The movements soon ceased, but she became completely hemiplegic on the right side, completely aphasic and incontinent. She appeared to be perfectly conscious, although unable to say a word or to make much response to orders. About a fortnight later she was admitted into the National Hospital, Queen Square, where she gradually became more comatose and died on May 9, exactly six weeks from the onset of her illness. The early stages of this illness were afebrile and no abnormal condition was found in her heart, lungs or kidneys. During the last few days of life her temperature varied between normal and 102° F., and at that time there was some albuminuria.

At the post-mortem examination the surface of the brain was noticeable for the presence of some dark reddish-brown staining in the subarachnoid space, evidently due to slight hæmorrhage on the surface of the cortex. This was most marked over the parietal lobe on the left side, but there were small patches scattered here and there in other parts of both hemispheres. Sections of this brain presented all the characteristic appearances of a hæmorrhagic encephalitis without the occurrence of any large hæmorrhage.

Case 18.—The patient was first seen on May 6, 1918. She was aged 44, and complained that she had not been feeling well for some time, but she had had nothing particular to complain of until Thursday, May 2, when she had some difficulty in doing her work owing, as she explained, to a deficiency in her mental grasp. On the following day she displayed some awkwardness and clumsiness in her right hand, and on the third day the whole of the right arm was weak. On this day she had an epileptic attack, involving and confined to the right side of the body, and this attack was repeated at intervals on the Sunday and Monday, with the result that she became more and more hemiplegic, more aphasic, and distinctly drowsy. She vomited on one occasion.

On the Monday evening she lay in bed in a lethargic condition, unable to speak, but evidently able to understand some commands, and able to indicate when she wanted to perform natural functions. She was taking her food well, and had little or no rise of temperature. There was complete right hemiplegia, with the usual reflexes, some right hemianæsthesia and complete right hemianopia. Her condition remained much the same during the next two days, and a lumbar puncture was performed, the fluid removed being at increased pressure but quite clear, and on microscopical examination normal in its cytology. The Wassermann reaction was negative. At this time she appeared to be suffering from severe headache, and on Thursday mid-day she was distinctly more stuporose, had become incontinent, was swallowing with difficulty, and showed some tendency to ptosis in both eyes. For the first time the optic discs showed slight swelling and blurring of the upper and inner edges.

She was obviously suffering from increased intracranial pressure, and a decompressive operation was decided upon. This was carried out by Colonel Sargent at 10 o'clock in the evening. She was trephined over the left post-central and temporal regions, and as soon as the bone was removed it was noticed that the dura was bulging, very thin, and easily torn. The brain surface presented a dark purple colour through the dura, and, on opening the latter, there was found great increase of tension. Shreds of recent clotted blood were scattered about, both beneath the dura and in the subarachnoid space. The cortex was hyperæmic and easily ruptured. The post-central vein was firm and thrombosed, and towards the vertex of the hemisphere the brain matter was deeply blood-stained and partly disintegrated. A sample of blood was taken up in a sterilized pipette for culture purposes, but nothing was grown from it. The patient died the following morning, and the post-mortem examination was made the next day.

The brain had on casual inspection the appearance of one from a case of cerebral hæmorrhage, but closer investigation revealed the presence of thrombosed veins on the surface of the left hemisphere, and one or two patches of what looked like hæmorrhagic infarction on the opposite side. After hardening, sections through the organ showed the presence of widespread encephalitis, confirmed by microscopical examination. All parts of the brain were not equally affected, and it has been characteristic of most of these cases that the inflammation has been patchy in its distribution—although there has generally been one large focus where the process has been most intense and most hæmorrhagic.

The account of this case is particularly interesting when compared with Case 3.

Case 19.—This patient was first seen on July 24, 1918. His age was 58, and he had always enjoyed good health until about three months previously, when he began to show forgetfulness and to do odd things, such as leaving off an article of his usual clothing. About the same time he began to complain of headache. For about a month there must have been some difficulty of sight, as his attempts to play croquet—at which he had been quite good—had become laughably bad. On Thursday, July 18, he had stayed away from business, not feeling well, and on Saturday he vomited incessantly, and complained of severe headache and pain in his legs. His temperature was about 100° F. on Saturday and Sunday, and on Monday he became distinctly worse, more drowsy, and somewhat aphasic. On this day right hemianopia was detected. On the Wednesday he was lethargic, and obviously very ill. His pupils were active. Both discs were slightly swollen with engorged veins, but no marked neuritis. There was complete right hemianopia associated with object blindness. He was quite unable to name objects, although he seemed to appreciate what they were when he saw them. If a key was put in his right hand he used it in a normal fashion, but he could not name it. He had obvious difficulty in understanding what was said to him, and made mistakes in carrying out orders. His temperature was then normal. There was no actual paralysis, the knee jerks were rather sluggish, the right being more brisk than the left, and on the right side an extensor response could be elicited. The blood and cerebro-spinal fluid were examined. The blood-count was practically a normal one and there was certainly no marked degree of leucocytosis. The cerebro-spinal fluid contained a considerable quantity of blood, and in addition there were some cells showing fatty degeneration which were not of blood origin.

The patient showed no signs of improvement, and it was decided that an operation for the relief of pressure should be undertaken. This was carried out by Colonel Sargent on August 1st, when he exposed the brain in the left post-central and occipital regions. Intracranial tension was increased, and the dura before being opened looked plum-coloured and opaque. When incised it appeared that there had been slight patchy hæmorrhage between its layers, and the cerebral surface was stained yellow. Blood was present in small quantities between the dura and the pia mater, here and there as a thin film and clot, elsewhere as darkish fluid blood. The fluid part had evidently sunk down towards the base, for on retracting the lower part of the exposed brain dark blood welled up in considerable quantity. The convolutions were flattened and pale, and here and there were lengths of thrombosed cortical veins. Just below the posterior end of the first temporal convolution was a spot which showed considerable softening, but there was no evidence of tumour or abscess anywhere. The patient stood the operation well, but was very restless during the following night, and later became almost maniacal. He began to refuse food, and his bladder had to be emptied by catheter for a couple of days. The headache was much relieved by the operation, but the patient gradually became more comatose, and died about ten days later. There was no post-mortem examination in this case, but no doubt can be entertained as to the diagnosis of lethargic encephalitis in view of the clinical history, and of what was seen at the operation.

Case 20.—The patient was a man of about 50 years of age, first seen on September 15, 1915. There was a history that early in August when working in a field in the country he had fallen down unconscious, had been delirious for a few hours, was seen by a doctor, and diagnosed as sunstroke, and that he continued to complain of headache and vertigo. He remained in a stationary condition until about September 13, when he was seized with very severe pain in the head, had several epileptiform convulsions, and, on examination, presented evidence of slight hemiplegia and some hemianopia. He was drowsy and difficult to examine, but he showed no signs of cardio-vascular disease, and his optic discs presented no change. The urine was normal. He was moved into St. Thomas's Home on September 16, and a lumbar puncture was performed on the same day. Very soon after this operation he had a general convulsion, and died quite suddenly.

The post-mortem was made the next day, when the brain presented the naked-eye appearances of cerebral hæmorrhage without any evidence of arterial changes. Portions examined microscopically displayed the characteristics of encephalitis.

The story of these four cases, coming so close together, appears to me to be one of unusual interest. All four patients were over 40 years of age, but none of them presented cardio-vascular changes suggesting the possibility of cerebral hæmorrhage as a diagnosis. In none of the four cases did the clinical history conform closely to that of cerebral hæmorrhage, but suggested some more subacute lesion, and naturally gave rise to the question of abscess or syphilitic thrombosis. In all four cases the Wassermann reaction and other features of the cerebrospinal fluid were negative. The lesson learnt from this experience is that patients over 40, and even over 50, years of age, may be the victims of encephalitis, producing the general symptoms of hemiplegia, aphasia, hemianæsthesia, or hemianopia. In the second place it seems that a naked-eye examination of a brain on a post-mortem table is not sufficient to discriminate between an ordinary cerebral hæmorrhage and a hæmorrhage which is only an accidental occurrence in the course of an encephalitis. It teaches us that when there are no obvious gross signs of disease in the cerebral arteries to account for a hæmorrhage, it is essential that microscopical investigation should be carried out in order to determine the cause for the blood extravasation. Thirdly, we must look on the presence of thrombosed cortical veins associated with hæmorrhage in the neighbouring brain substance as strongly indicative of an inflammatory process.

There is no reason to suppose that lethargic encephalitis is a new disease, and we may justifiably assume that endemic cases occur from time to time. Most of us can recall patients suffering from symptoms of acute or subacute cerebral disease, in connexion with whom a hesitating diagnosis of cerebral hæmorrhage has been made, and others again of whom a diagnosis has never been properly established. This recent epidemic is of practical importance in that it ought to bring the possibility of encephalitis more prominently before our minds in cases of cerebral disease presenting difficulties in diagnosis. At the present moment this realization may not be of much practical importance, because we are not yet in a position to say what is the nature of the infection, or to point to any method of treatment likely to abort or cure the disease. The experience of these four cases, however, suggests that operative intervention in the way of decompression is really contra-

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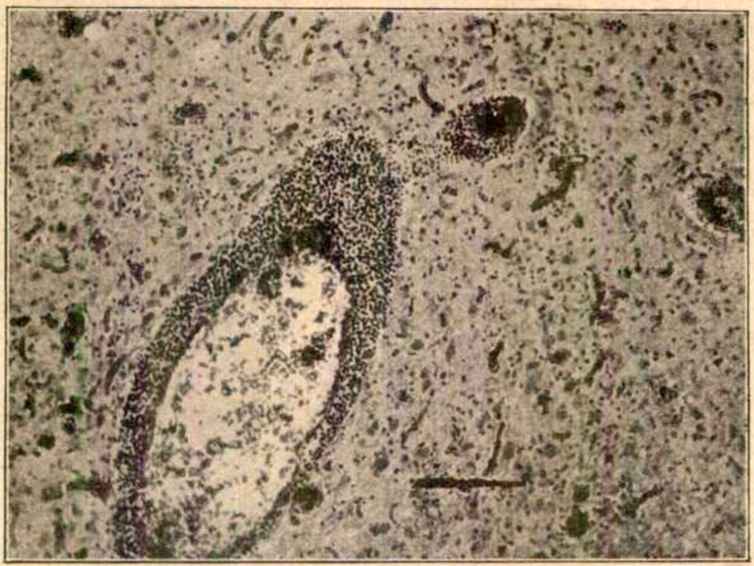


FIG. 1.—Case 17. Cortex. The typical "cuffing" of the medium and small-sized veins of the cortex is shown, as well as the great congestion of the capillaries. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

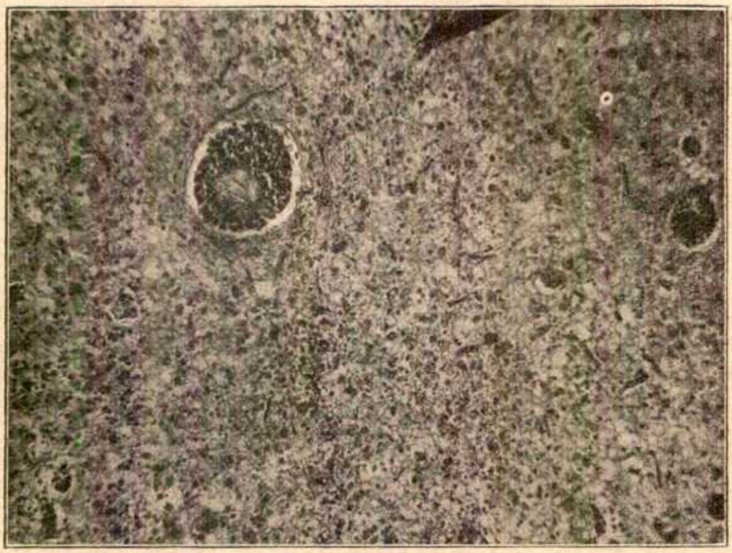
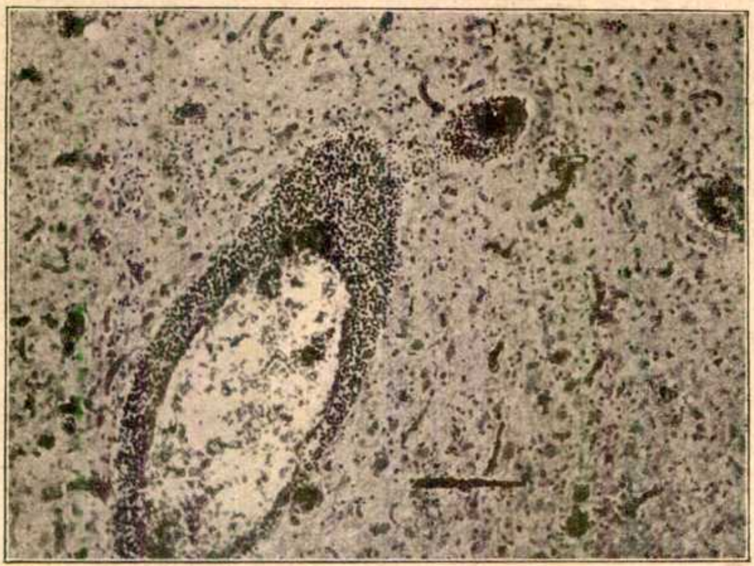


FIG. 2.—Case 17. Cortex. A vessel is seen with a fibrinous clot in its lumen, and surrounded by a thick ring of small round cells. Great glial overgrowth is seen in the surrounding nervous tissue. (Zeiss 16 mm. obj. Comp. ocular No. 4.)



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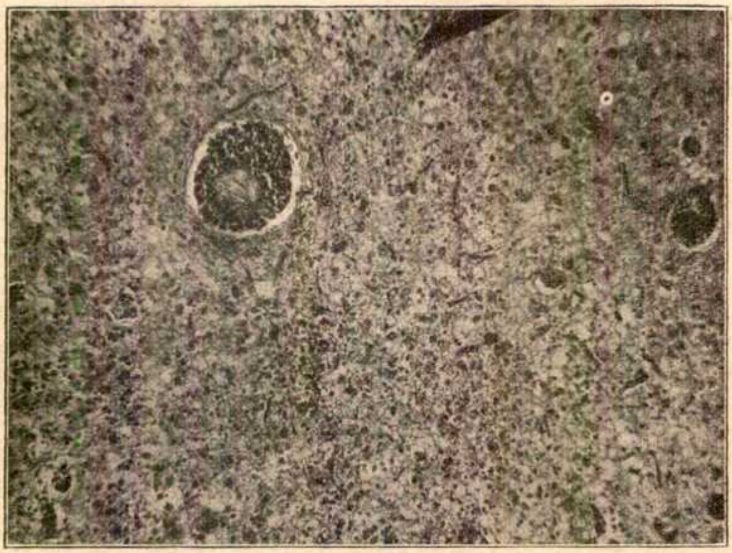

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stretching which the glial fibres undergo in this process is evidenced by a tangential concentric arrangement of the innermost glial layers (see fig. 11). Many of the nerve cells show a moderate degree of chromatolytic change, and some have a few phagocytic cells in relation to them.

Upper part of medulla (at level of olivary body and nucleus of twelfth).—Here the meninges have undergone a general but slight infiltration with lymphocytes and plasma cells. This is greatest in the immediate neighbourhood of the vessels. Several vessels in the posterior part of the medulla around the twelfth nucleus and under the floor of the fourth ventricle show considerable adventitial infiltration. In some vessels this is represented by two crescents of small round cells on the opposite sides of the vessel wall, the intervening space being clear. In others the adventitial infiltration is more general. Most of the nerve cells of the twelfth nucleus are healthy, but in some the Nissl granules are in a powdery condition, and one or two "parasitic" cells are seen in contact with the nerve cell body. These are sometimes glial cells, but often appear to be of fibroblastic origin, having long nuclei, the ends of which are rounded. Others are typical plasma cells. Some of the smaller nerve cells in the same region illustrate a greater degree of the process of neuronophagy; their protoplasm has almost disappeared, and four, five or more small round cells have settled down in close contact with them.

The cells of the olivary nucleus appear fairly healthy. There is a general increase of cells in the interstitial tissue, especially in the posterior part of the section. This is largely accounted for by the emigration of plasma cells and other mesodermal cells into the nervous substance. There is also a certain amount of glial increase, but this has not reached the same profusion as in the cortex.

Medulla (level of decussation of pyramids).—Here there is a patchy infiltration of the meninges with small round cells, among which are many plasma cells and a few polymorphonuclear leucocytes. This occurs chiefly in the neighbourhood of the meningeal vessels. At this level a few vessels in the medulla are surrounded with a thick ring of small round cells. In many other vessels the same infiltration of the adventitial sheath is seen, but to a less degree. There is also an increase of cells, mainly small round cells along the walls of some of the capillaries, but this is not very general. The majority of the large nerve cells of the anterior horn at this level show no abnormality beyond a moderate excess of pigment.

Case 18.

Cortex and meninges.—A few of the medium-sized vessels on the surface of the brain have undergone thrombosis. In the case of a thrombosed vein of medium size (fig. 4) lying in a sulcus of the cortex, the underlying brain matter of the subcortical layer is ploughed up with hæmorrhages, most of which are of very small size but confluent, so that in places little evidence is left of brain tissue. In what is left almost all the small vessels are thrombosed, and there is a great increase in the number of glial nuclei. There is also a proliferation of cells along the walls of the capillaries. There is in this region no infiltration of the vessel sheaths with round cells.

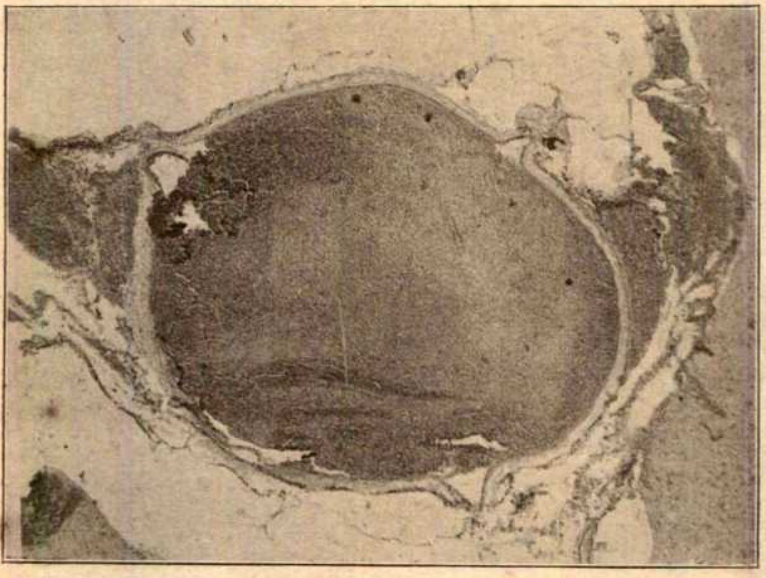

FIG. 4.—Case 18. Large cortical vein completely thrombosed. (Magnification × 35.)

The arachnoid space round this thrombosed vein is full of red blood corpuscles, among which are many polymorphonuclear and mononuclear phagocytic cells.

In another part of the cortex there is an artery lying in a sulcus which has an extensive hæmorrhage into its walls on one side, and a mass of phagocytic cells encroaching on its lumen on the other side. The cortex on one side of this sulcus is almost completely necrosed, showing a wedge-shaped area of diffusely staining tissue in which only a very few palely staining nuclei are seen, along with very numerous

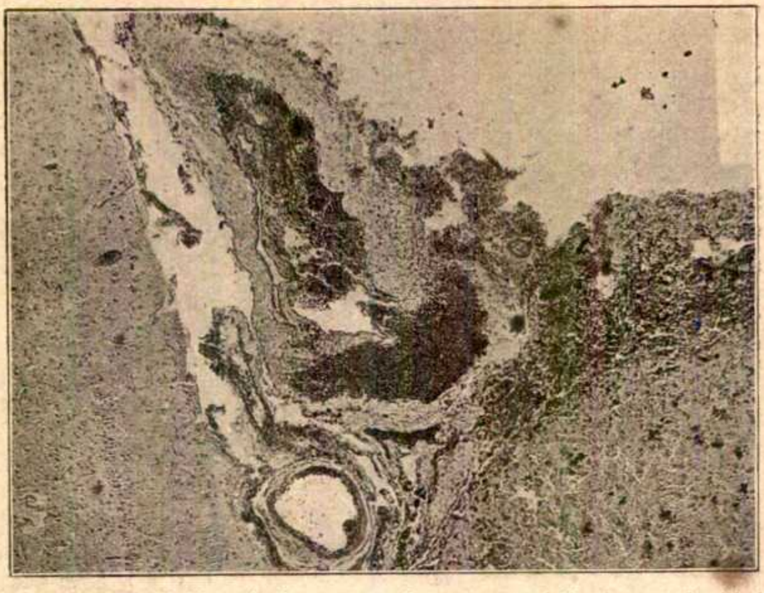

FIG. 5.—Case 18. Medium-sized artery on the cortex partially obstructed with hæmorrhage in its walls, and leading to small wedge-shaped area of infarction, a corner of which is seen in the right lower corner of the figure. (Magnification × 35.)

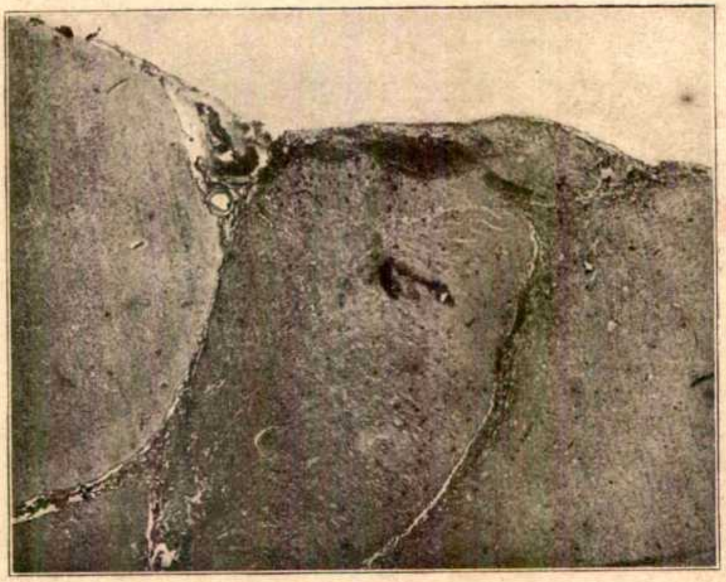

FIG. 6.—Case 18. View of wedge-shaped area of infarction caused by obstruction to cortical artery seen on surface. (Magnification 10 diameters.)

petechial hæmorrhages and a few phagocytic cells. This area is delimited on one side by the sulcus, and on the other by a fairly sharp line along which runs a thin zone of softened brain tissue containing many compound granular corpuscles, and numerous smaller rounded and elongated cells. This zone shades off into fairly normal brain tissue through an intermediate zone in which the nerve cells are more or less degenerated, and there is great increase in the glial elements. The vessels in this zone have their adventitial spaces filled with phagocytic cells from the degenerate area, but otherwise show no change. This zone shows many newly formed glial fibrils arranged tangentially to the degenerated zone. (See figs. 5 and 6.)

In this area there is considerable hæmorrhage into the meninges, and the blood is being absorbed by large phagocytic cells.

Optic Thalamus.

Vessels.—There is only very slight increase in the number of cells in the adventitial sheaths and many vessels show no change at all. There is everywhere an increase of cells along the small capillaries, showing in many places as chains of three or four small rounded nuclei. There are a very few perivascular hæmorrhages.

Nerve cells.—Most of the larger nerve cells of the thalamus show a great excess of pigment and some perinuclear chromatolysis. A great number of the cells are surrounded with two or more phagocytic cells. The glial cells are everywhere increased in number.

Midbrain and pons.—Here the changes are similar in character to those seen in the thalamus but less definite. There is a very slight increase in the number of cells along the walls of the capillaries and smallest arterioles and venules, and an increase of pigment with some neuronophagy in the nerve cells of the oculomotor nuclei.

Medulla.—No definite changes can be made out here except a slight infiltration of the meninges with small and larger mononuclear cells.

Case 20.

Pieces were taken from the neighbourhood of the hæmorrhage into the basal ganglia and from the cortex.

Meninges.—In several places there are small subarachnoid hæmorrhages. Here, in addition to the red blood corpuscles, there is a considerable degree of small-celled infiltration. A few of the smaller meningeal vessels are thrombosed, their lumen being filled with phagocytic cells, a considerable proportion of which are polymorpho-

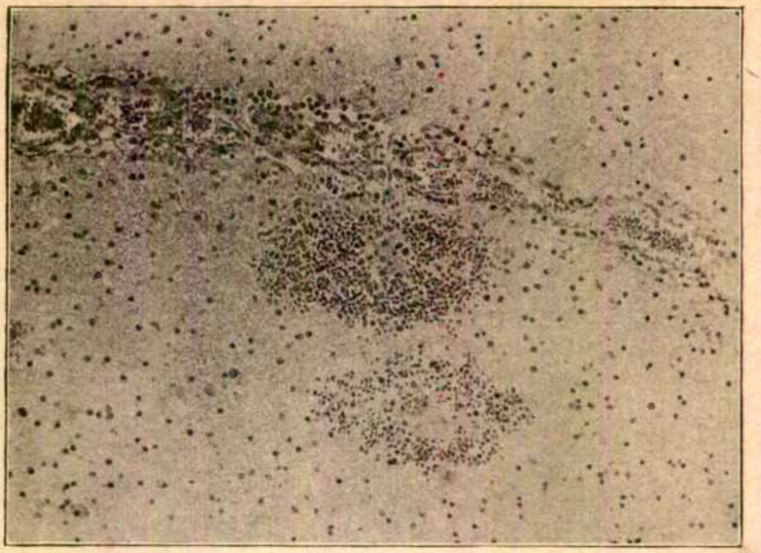

FIG. 7.—Case 20. View of longitudinal section of a small blood-vessel in the cortex. The adventitial sheath is seen to contain numerous small round cells. Two petechial hæmorrhages are seen close to the vessel. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

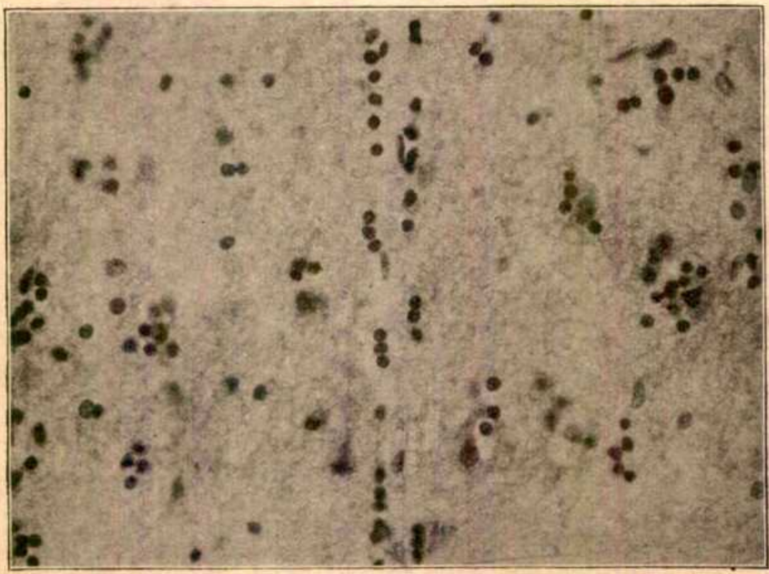

FIG. 8.—Case 20. Cortex. A capillary vessel is seen in the centre of the field, showing short chains of small round cells along its walls. Note the neurophagy of the small nerve cells in the neighbourhood. (Zeiss 8 mm. obj. Comp. ocular No. 4.)

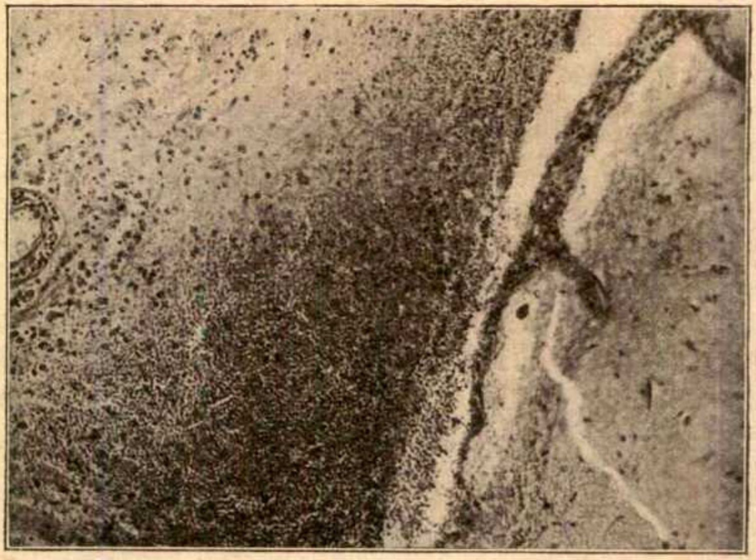

FIG. 9.—Case 20. Field showing an area of hæmorrhage into the arachnoid. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

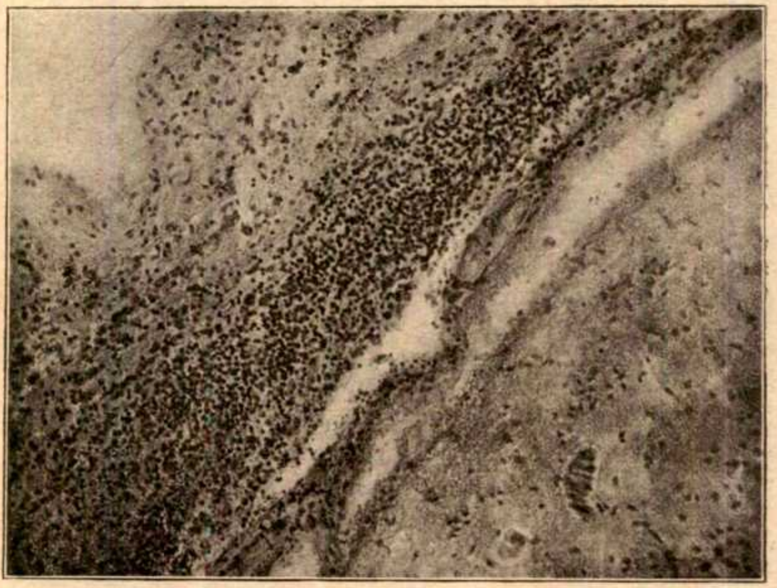

FIG. 10.—Case 20. View of cortex and meninges to show the patchy infiltration of the meninges with small cells. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

nuclear. Among the red corpuscles there is also a fair proportion of polymorphonuclear leucocytes. It is to be noted that only a small minority of vessels show thrombosis, but all show great dilatation.

Cortex.—There is comparatively little abnormality in the superficial layers of the cortex. The nerve cells show an excess of pigment and all degrees of chromatolysis.

In the deeper layers of the cortex there is everywhere considerable vascular congestion, and in places there are small perivascular hæmorrhages. In a few places close to the smaller vessels there are small collections of serum, as though a leak had occurred in the vessel wall, which was too small for the escape of blood corpuscles but had allowed the fluid contents of the blood to exude. In this area there is a great increase of nuclei in the walls of the blood-vessels, and this is to be seen even in the finest capillaries, many of which are outlined by a chain of rounded nuclei. (See fig. 8.)

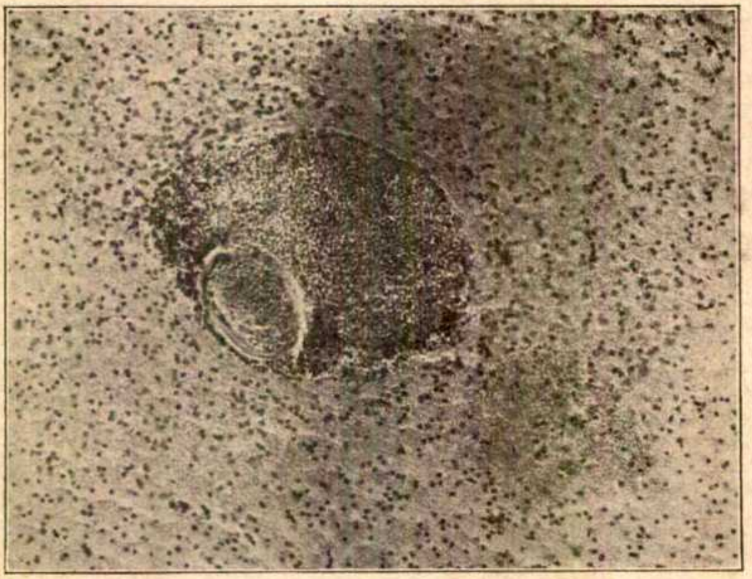

FIG. 11.—Case 20. Hæmorrhage into the perivascular space in a small cortical artery. Note the concentric lines of glial fibres due to distension by hæmorrhage. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

In the subcortical region, in one or two places, this vascular congestion and perivascular hæmorrhage reaches a maximum, so that most of the tissue is ploughed up with hæmorrhages. In the neighbourhood of such areas it is usually possible to find a fairly large vessel thrombosed, and it is impossible to avoid the conclusion that the local congestion and hæmorrhage occur at the edge of an area of infarction, and are due to the cutting off of the main blood supply to the part.

Basal ganglia.—In this region the brain substance shows the same changes as in the subcortical layers—viz., vascular congestion, and perivascular hæmorrhages, in some places reaching a maximum and leading to massive hæmorrhage.

Case 21.

The following pathological report concerns the case of a young woman who died in the National Hospital about four months after the onset of a characteristic and severe attack of encephalitis lethargica which rendered her bedridden until the time of her death.

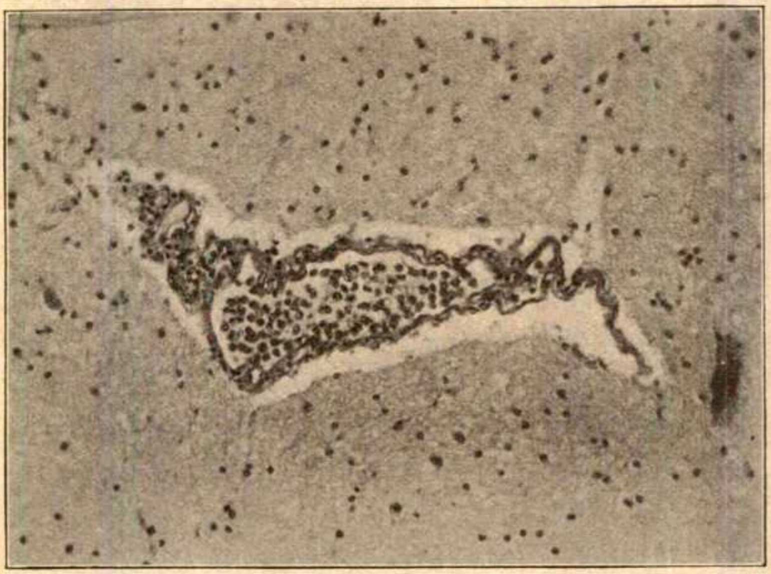

FIG. 12.—Case 21. Blood-vessel in medulla filled with fibrinous clot which is being absorbed by phagocytic mononuclear cells. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

Pieces were taken from the basal ganglia, cortex, midbrain, pons and medulla.

Meninges.—There is everywhere a small degree of infiltration of the meninges with small round cells. Very few polymorphonuclear cells are seen here, but there is a fair proportion of cells with small pyknotic nucleus and relatively abundant cytoplasm. A small proportion of the vessels show evidence of thrombosis of fairly old standing; in a few

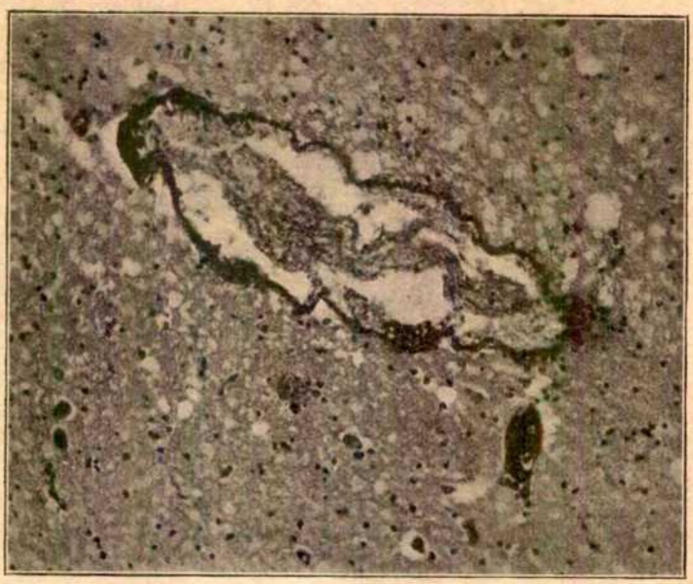

FIG. 13.—Case 21. Basal ganglia. Medium-sized vein showing thrombosis and calcareous degeneration of its walls. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

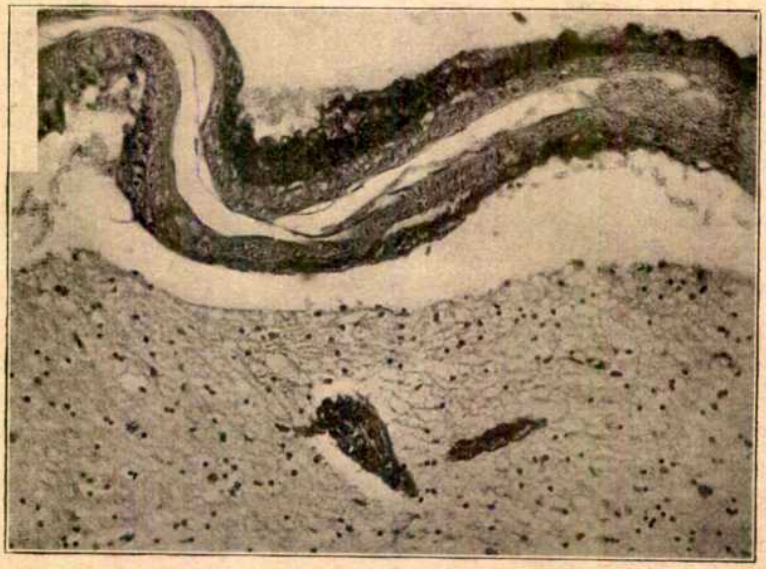

FIG. 14.—Case 21. Lenticular nucleus. A medium-sized artery is seen with extensive calcareous degeneration of its outer coat. (Zeiss 16 mm. obj. Comp. ocular No. 4.)

the fibrin clot is still unabsorbed, and contains large phagocytic cells in its meshes.

Cortex.—The chief change here is in the vessels, a very large proportion of which are thrombosed. Many of the small veins which are thrombosed show no cellular reaction round their walls, but their lumen is filled with fibrin containing a greater or smaller number of large mononuclear phagocytes. The small arteries all show thickening of the fibrous tissue elements in their walls, with more or less infiltration with small round cells in the adventitial lymphatics. Many of them are thrombosed, but the most remarkable change is a calcareous degeneration both of the walls of the vessels and of the thrombus. This is seen more in the larger than in the smaller vessels, and is not nearly so universal in the cortical vessels as in those of the basal ganglia. The vessels which show this change are all thrombosed, and most of them contain an excess of small round cells in the adventitial spaces. (See figs. 13 and 14.)

There is a moderate increase in the number of glial nuclei both in the cortical and subcortical layers, and a few of the capillary vessels show a slight increase in the number of cells in their walls, but this is insignificant compared to the changes in the larger vessels.

The nerve cells of the cortex show slight degrees of chromatolysis, but few show any great degree of degeneration. Most of them show some excess of pigment, but this is not so great as in the cells of the basal ganglia. Only a few of the cells show neuronophagy.

Basal ganglia.—Here the majority of the vessels show thrombosis at some stage of resolution, very many of them having calcareous deposits either in the walls or lumen. There are also some calcareous deposits in the tissues close to large thrombosed vessels. Some of these seem to result from the calcification of thrombosed arterioles, while others are due to deposit of lime salts in areas of perivascular hæmorrhage or effusion of plasma. For the most part it is only the largest thrombosed vessels which show this change. All the vessels show some degree of infiltration of their walls with round cells. The nerve cells are comparatively little affected, only a few of them showing neuronophagy, but all show a considerable excess of pigment. There appears to be a general increase of neuroglial nuclei, and some enlarged neuroglial cells are seen everywhere.

Junction of pons and midbrain.—A great number of the vessels here show thrombosis and there is more infiltration of the adventitial lymphatic sheath with round cells than in the cerebrum. This is patchy in that it is of greater degree in some vessels than others, but all show at any rate some increase of cells in their walls. One thrombosed artery in the ventral region of the midbrain on either side, near the point of emergence of the oculomotor nerve, shows great increase in the amount of adventitial fibrous tissue and the spaces of this coat are packed with round cells; the majority of which are the size of lymphocytes, the rest being larger, with more cytoplasm and more vesicular nucleus.

The majority of the vessels in the region around the iter of Sylvius are thrombosed and their lumen is full of phagocytic cells of fairly large size. (See fig. 12.)

The nerve cells show only moderate chromatolysis. There is little neuronophagy. There is a slight glial increase, not greater than that seen in the basal ganglia.

Medulla.—Here only a few vessels show any evidence of small-celled infiltration of their walls.

A few of the cells of the nuclei are absolutely normal. Others show some perinuclear chromatolysis and excess of pigment, and a few have eccentric nuclei. Most of the cells of the olivary nucleus are swollen with pigment which displaces the nucleus. This appears to be somewhat in excess of the normal, but these cells very frequently contain much pigment. Otherwise there is very little abnormality.

Case 22.

The following pathological report concerns the brain of a soldier between 20 and 30 years of age, who was admitted into a London military hospital from France with a diagnosis of debility following influenza.

On admission he complained of intense headache and photophobia and was markedly lethargic. The lethargy increased and he became incontinent. Although difficult to rouse he could generally be made to answer questions intelligibly, but he showed some signs of right hemiplegia before he died. Lumbar puncture was performed on three occasions, and the fluid which was drawn off was always found to be normal in regard to its chemical, cytological and bacteriological contents. The blood showed a slight leucocytosis with a relative increase of polymorphonuclear cells.

Cortex.—There is a little meningeal infiltration and a certain amount of proliferation of the endothelium of the walls of the meningeal vessels. The vessels of the cortex are congested, but there is no round-celled perivascular infiltration. There is, however, evidence of proliferation of cells round the smallest capillaries, showing as rows of three to six small round cells just outside the capillary wall.

The majority of the nerve cells show no abnormality, but a few have lost their Nissl granules more or less completely, and in close contact with these cells there is a number of small round cells. In some cases the body of the nerve cell appears to be replaced by a cluster of such cells. These parasitic cells give with toluidin blue a purer blue staining than the nerve cells, which take on a more purple colour. The chromatic points in their nuclei are arranged around the periphery in the manner seen in plasma cells. But they are for the most part smaller, with rather less cytoplasm than the fully formed plasma cell. The cytoplasm is clear and hyaline, and contains no granules which take up the ordinary stains. Its refractility is fairly high, so that in sections stained with toluidin blue it stands out clearly from the colourless ground substance as a clearly defined white ring.

The ground substance both in the cortical and subcortical layers contains far more nuclei than normal, the majority of which belong to cells of the type just described, leaving a minority of typical glial cells.

In the *precentral convolution* the majority of the Betz cells show little abnormality, but there is here the same excess of small round cells as elsewhere.

Midbrain (below level of nucleus ruber).—The meninges here show only a slight degree of proliferation of endothelial cells, and infiltration with small round cells. No thrombosis of vessels is seen. The majority of the medium-sized vessels and small vessels in the midbrain show perivascular infiltration of greater or less degree. In some of the smaller vessels this forms a cuff as thick as the lumen of the vessel, but this is exceptional. In most cases only one or two layers of small round cells are seen in the adventitial lymph spaces. The multiplication of cells along the walls of the capillaries is well seen here. Most of the cells of the oculomotor nucleus are fairly healthy, but a few show loss of Nissl granules and neuronophagy. The same may be said for the cells of the substantia nigra. The affected cells in both nuclei are scattered irregularly among perfectly healthy cells. There is, however, here as elsewhere, a general increase in the number of glial and mesoblastic cells in the ground substance.

Junction of pons and midbrain.—Here several of the larger veins in the ventral part of the section show recent thrombosis, with collections of polymorphonuclear and a few mononuclear cells in the fibrin. In the dorsal part, under the upper end of the fourth ventricle, the majority of the vessels show a considerable degree of perivascular infiltration.

The nerve cells of the fourth nucleus show similar changes to those in the higher oculomotor nuclei, the ratio of degenerated cells to normal cells being a small one. Most of them show, however, an increase in the amount of pigment. The cells of the motor nucleus of the fifth are apparently healthy, as are those of the seventh. Similar but less pronounced changes are seen on passing down the pons. There is some recent thrombosis of some of the smaller meningeal veins over the ventral surface of the pons.

Medulla (level of the olivary body).—There is considerable patchy infiltration of small round cells in the antero-median fissure. The cells of the twelfth nucleus are normal, but there is very general infiltration of cells in the tissues under the floor of the fourth ventricle, and several of the larger vessels in this region are ringed with round cells. In the region of the olive this infiltration appears to be less, and there is only a slight excess of glial cells among the cells of the olivary nuclei.

In the nucleus gracilis and cuneatus the cells appear healthy enough, but there is more general infiltration than normal.

Lower part of medulla.—Level of decussation of pyramids. Even down to the lowest level of the pyramidal decussation a few small vessels show small-celled cuffing of their walls, and there is a slight degree of meningeal infiltration. These changes become progressively less on passing from the upper to the lower end of the decussation. In this region no alteration in the nerve cells can be found.

Discussion of the Histological Findings.

In discussing the histological changes found in "encephalitis lethargica" we take the liberty of drawing certain observations from cases, not included in this series, which have found their way into the laboratory of the National Hospital from a variety of sources. In particular may be mentioned a case of Dr. Deas, which was examined for Dr. Grainger Stewart, through whose courtesy we are able to refer to it. This case provided the slightest changes which we have encountered in this disease.

It will have been seen from the detailed account given above, that the histological appearances of the brains examined were very various.

Some of these are accounted for to a large extent by the varying intervals between the onset of symptoms and the fatal termination. Others were present in cases which relapsed several weeks after the beginning of the illness, and may be accounted for by this. Others may be due, to some extent at least, to the age of the patient.

But there are certain features common to all cases in the early stages, which may be briefly summarized. They are:—

(1) Vascular congestion.

(2) Evidence of toxic degeneration of the nerve cells and neuronophagy.

(3) Proliferation of the mesoblastic cells of the vessel walls, and infiltration of the nervous tissue with these cells.

(4) Small-celled infiltration of the Virchow-Robin space.

(5) Glial proliferation.

These are given in the order in which they occur most constantly and most generally in the cases we have examined.

(1) Vascular congestion has been the most striking feature of all the cases examined within the first few weeks of the onset of symptoms. It affects all the vessels down to the smallest capillaries.

(2) The changes in the nerve cells are extremely constant, but they are by no means universal. Some of the nuclei of the brain stem may show very little change when others close to them have many cells affected. In general only a few of the nerve cells of a nucleus or area are affected, but all may show some degree of alteration. These changes, which have been well described by Marinesco, are perinuclear chromatolysis, eccentricity of the nucleus, excess of pigment, and, perhaps most constant of all, neuronophagy.

(3) It seemed clear that the cells taking part in this neuronophagy were, for the most part, derived from the mesoblastic elements, many being closely allied to plasma cells. They resembled in every respect the rows of round cells which could be seen in the same field lying along the outside of the capillary walls (fig. 8). Their cytoplasm is free from granules, and its outer border is rounded and clearly defined, and they occur at a stage of the disease when there is little evidence of glial proliferation. They were seen in large numbers among the nerve cells of the most affected nuclei, and to a less extent throughout all the nervous tissue. In some parts of the cortex, and in a few of the nuclei of the brain stem, almost every nerve cell had several such cells in close relation to it.

In one or two of the cases which showed the greatest changes there are small collections of such cells in some parts of the pons and midbrain. But dense clusters of cells such as those which invade the anterior horns of the cord in cases of poliomyelitis were never seen.

(4) Round-celled perivascular infiltration was present to a greater or less degree in all the cases examined within the first month or two of the onset of symptoms. But in two cases it was so inconspicuous a feature that a careful search was necessary to find any vessel which showed this change. It is not nearly so universal as is the infiltration of the tissues with plasma cells and lymphocytes, and is always patchy; either it picks out only a few vessels, or when the majority are affected they show great variety in the thickness of the cuff of cells with which they are surrounded. These cells may obviously either be leaving the blood-vessel or returning to it. Several observations tend to support the theory that the majority of these cells are on their way back to the vessel.

(*a*) It is well known that in degenerative diseases of the nervous system the Virchow-Robin space around the veins becomes distended with scavenger cells laden with the products of myelin destruction. It is therefore reasonable to suppose that the current, if any, in this space will be from the tissues to the vein.

(*b*) It is so common as to be almost constant in the cases examined to find collections of small round cells in the meninges in the neighbourhood of the larger veins. As the Virchow-Robin space opens into the pial lymphatics in close relation to the emerging vein, and these again communicate with the subarachnoid space in the vicinity, it is reasonable to suppose that these collections of cells may represent the effluent from the tightly packed perivascular sheaths seen in the neighbouring nervous tissue.

(*c*) Especially in the earlier cases of the disease, it is common to find a very considerable degree of general infiltration of the nerve tissues, and neuronophagy of the nerve cells in an area of the brain where no perivascular infiltration can be found, or where it occurs to only a minimal extent.

(5) In most of the cases there was some evidence of glial proliferation, but this formed a conspicuous feature in only one case (Case 17). This patient died at the end of the sixth week of the disease and showed the typical changes of the disease in an extreme degree. In the subcortical layers there was a great proliferation of neuroglial cells, showing themselves as large irregular cells, with long fleshy processes, and one or more oval nuclei lying near the margin of the cell.

If the only evidence we accept of the early stages of neuroglial proliferation is the presence of glial cells with more than one nucleus, and still more if we regard these large *amœboid* forms as necessary to glial multiplication, we must conclude that this change, although obvious enough in some cases, is not a conspicuous feature of the majority.

Venous Thrombosis and Hæmorrhage.

Although neither of these phenomena are constant in the disease in the cases we have examined, both are sufficiently common in our cases as well as in those described by others to deserve mention. Venous thrombosis appears to be rather more constant than hæmorrhage. Either the largest veins on the cortex or the smallest venules in the substance of the brain or brain stem may be affected, and we have seen such thrombi in all stages of resolution. In the cases which died within a few weeks of the onset of the disease thrombosis was evidenced by a fibrin reticulum occupying a part or the whole of the lumen of the vessel. This usually contained a large number of polymorphonuclear leucocytes and lymphocytes in its meshes, which may be taken as evidence that the clotting had occurred several hours at least before death. The presence of a fibrin reticulum which did not contain leucocytes was not considered to indicate necessarily pre-mortem thrombosis. In the case which showed the most extensive changes (Case 20) a few vessels were seen which showed such a fibrinous coagulum as well as perivascular infiltration and hæmorrhage into the surrounding tissues.

Hæmorrhage seemed to be due definitely to two distinct causes. The commoner form is that where a smaller or larger ring of hæmorrhage surrounds a congested vessel. Such hæmorrhages take place, at any rate in the first instance, into the so-called perivascular space of His, tearing the glial fibres away from the vessel walls and stretching them in a tangential manner (see fig. 11). In some cases, whether from the greater pressure at which the hæmorrhage has occurred or the greater fragility of the glial tissue, the hæmorrhage breaks through this ring, and spreads into the tissues for some distance from the vessel. This form of hæmorrhage usually occurs round veins. It is patchy and irregular, affecting only one or two out of many vessels in a section. It is most often seen in the cortex and in the grey matter under the floor of the fourth ventricle.

Infarction.—The other form of hæmorrhage is that due to infarction. Here there is usually a central focus in which the nervous tissue is ploughed up with multiple hæmorrhages, and is completely necrosed, and at the edge of this area there are seen numerous petechial hæmorrhages lying in the tissues at a greater or smaller distance from the vessel from which they seem to arise. In some cases the thrombosed artery which gave rise to the infarction can be seen in the section, but its presence can always be inferred from the characteristic changes. The hæmorrhages in this case seem to take place from small arterioles, and evidently occur at much greater pressure than in the previous form. They are of the nature of sudden spurts of blood into the tissues, on one or other side of a vessel, rather than the slow oozing of blood into the perivascular space of His which occurs in the other forms.

Such areas of infarction occurred in Cases 18 and 20 and the onset of this event seemed to be the direct cause of the rapid aggravation of symptoms to which they succumbed.

LOCAL PARALYSIS FOLLOWING SUPERFICIAL INJURIES NOT INVOLVING NERVE TRUNKS: WITH SPECIAL REFERENCE TO TRAUMATIC "ASCENDING NEURITIS" AND TO "REFLEX PARALYSIS."

BY F. M. R. WALSHE, M.D., M.R.C.P.

Assistant in Neurology, Medical Unit, University College Hospital, London.

INTRODUCTION.

AMONG the many difficult problems confronting the neurologist we must include a small group of cases of local paralysis after injury to a limb, in which no nerve trunk has been involved. These cases present the features of an organic peripheral nerve lesion, and commonly follow a trivial superficial injury to the distal extremity of a limb. Four cases of this type are reported in the present paper. In seeking for an explanation of these, two possible causes suggest themselves: they are "reflex paralysis" and traumatic "ascending neuritis."

The conception of *reflex paralysis,* once so popular and emphasized so strongly by Charcot and Brown-Séquard, has now been almost abandoned. It was formerly invoked to explain clinical phenomena having little in common; from a local palsy, peripheral in type, to a complete paraplegia. Irritation of sensory nerve endings in skin or viscera was thought to be the cause of the condition.

There is possibly one instance in which this explanation is still widely accepted—namely, to account for the rapid local muscular atrophy found in acute arthritis and in certain injuries of joints and epiphyses.

The onset of this is rapid. Muscles proximal to an affected joint waste. The wasting is not associated with any degree of tenderness, and until it reaches a profound degree the corresponding tendon-jerk may be normal or increased. Such loss of power as is present is entirely due to wasting, and some observers have stated that section of the afferent nerves of the joint will prevent this. There is therefore some justification for regarding it as reflex in origin, though this solitary fact is all that is known of its pathology.

The cases to be described here do not accord entirely with this clinical picture. They correspond in every instance to the result of a peripheral nerve palsy, in which there may be motor, sensory, reflex and vasomotor changes. Cases comparable with them have been recorded by Oppenheim [14] and by Kramer [9]. Thus Oppenheim's case was one of gunshot wound of the arm with fracture of the humerus. The wound healed readily, but when the patient came under observation three months later, there was a complete atrophic palsy of the deltoid, biceps, coracobrachialis and supinator longus; while triceps and the forearm muscles were weak. There was neither pain, tenderness, nor sensory loss, and the electrical reactions were normal. Oppenheim regarded the condition as due neither to neuritis, poliomyelitis, nor hysteria, but as a "reflex paralysis" comparable with the arthrogenic atrophies. It differed from these, however, in the presence of paralysis as well as wasting. He suggested that the neurospinal lesion was "dynamic," while the muscular result was "organic."

Kramer's case was almost identical in character and site with the Case 3 recorded in this paper, and he accepts Oppenheim's explanation in respect of it.

During the period of the war, Babinski elaborated a comprehensive symptom-complex of "troubles nerveux d'origine reflexe," for which he seems to have drawn largely upon phenomena hitherto widely regarded as hysterical in nature. Within its limits he has included many gross objective signs of nervous disorder: wasting and loss of power, hypotonus and contracture, exaggeration of tendon-jerks with loss of cutaneous reflexes, altered mechanical and electrical excitability of muscles, trophic and vasomotor disorders, and finally, marked subjective and objective sensory changes. These occur in various combinations and give rise to different clinical forms. According to Babinski, "these phenomena may be entitled *physiopathic*, a term intended to express the idea that, on the one hand, neither hysteria nor any other psychopathic state can produce them, and, on the other, that while indicating a physical and material disorder of the nervous system they do not appear generally to correspond to any nervous lesion that can be detected by the methods at our disposal." Further, "they tend to spread beyond the limits of any anatomical area" [2].

Considerable doubt has been expressed as to whether these symptoms are the manifestations of a true clinical entity, and not rather that of a medley of abnormal conditions, to which hysteria, the mechanical effects of secondary tissue changes and even local tetanus may contribute their share.

Nevertheless, it is possible that cases of the well-defined character of those which form the subject of this paper may have helped to swell the numbers of this apparently ill-defined and heterogeneous collection of clinical forms that Babinski has named "reflex nervous disorders."

The alternative explanation mentioned earlier is that possibly the cases to be discussed belong to that rare nervous affection known as "ascending neuritis." *Ascending neuritis* (neuritis migrans, neuritis ascendans, la névrite ascendante), like reflex paralysis, is an example of a condition once diagnosed freely, but now greatly out of fashion. One of the best early descriptions is that given by Remak in 1861. The case he recorded was in every way typical of those since described. The patient was a man who three months earlier had driven a splinter under the nail of a little finger. The wound healed in two weeks, but a progressive weakness and wasting of muscles supplied by the ulnar nerve followed, while the nerve trunk became tender and thickened. According to Bolten, who quotes the case [3], Remak regarded it as due to infection of the nerve terminations, whence "der Prozess in den Lymphbahnen des Nerven weiter aufwärts verbreitet hätte."

Of recent years numerous similar cases have been reported, though even yet the condition is not universally recognized, and must be regarded as exceedingly rare. The majority have been recorded in the French literature. By English and German writers it has been comparatively seldom referred to, and then mostly in terms of scepticism. Thus, Strümpell [16] does not believe that ascending inflammatory changes in a nerve take place, while Oppenheim [12] says that "as regards simple non-suppurative inflammation this mode of spread has not been sufficiently proved, although isolated clinical observations make it probable that neuritis may penetrate in the central direction from the site of its origin." Krehl, K. Mendel [12] and G. Bolten [3] have described and collected small series of cases of this nature, in Germany, but without any pathological confirmation. In France, Raymond and Guillain [16], Sicard [17], Aynaud [1], Leenhardt and Norero [10], Lejonne and Chartier [11], Brissaud and Gougerot [4], and finally Dejerine and Thomas [5 and 6] recorded cases during the ten years preceding the war, while since 1914 others have been observed by Guillain and Barré [8], and by Ferry [7]. Only the case of Dejerine and Thomas was confirmed by autopsy, and upon this examination rests all that we know of the pathology of the condition.

Sicard [17] has written the most comprehensive recent study of "ascending neuritis." He regards it as exceedingly rare, and defines it as a localized, slowly progressive lesion, ascending from the distal terminations of the nerve towards its central end. It is constantly associated with an infection of a cutaneous lesion in which nerve endings are infected, and the local reaction may be slight or severe. The nerve affected is that supplying the injured region. He describes three stages: that of a local peripheral reaction characterized by paroxysms of intense pain radiating proximally from the site of injury. This pain may become constantly present in all segments of the limb: it is aggravated by active or passive movements, and rapidly renders the limb useless, indeed it is described as being so severe as to render the patient's existence burdensome. Simultaneously, the pulp of the affected digit atrophies (for the lesion is almost always on a finger), the finger becomes tapering, and covered by glossy, atrophic and cyanosed skin, while the digital joints become ankylosed. Motor loss varies from a just perceptible local wasting to marked atrophy of small hand muscles with loss of power. Objective sensory changes are exceptional. Ultimately the trophic changes may involve the whole hand. Recovery is slow and partial and usually the condition tends slowly to progress.

Rarely, a second stage, that of "réaction à distance," occurs, due to involvement of the posterior root ganglia; pain now spreads, and spasm and tremor may appear. Sicard considers that a third stage of root and cord involvement is possible, but problematical. He does not believe that a sclerotic inflammatory process reaches the posterior root ganglia.

The lesion found in Dejerine and Thomas's case: one of ascending neuritis following a pinprick of the thumb, was a selective degeneration of afferent fibres in the median nerve. The fibres affected were those arising in the digital branches of the thumb and of the radial side of the index. The degenerating fibres could be traced into the sixth and seventh cervical posterior roots, and the cells of the corresponding ganglia showed changes. The roots themselves were markedly atrophied. The nerve showed no signs of old inflammatory interstitial reaction. It was not possible to trace the process into the cord as the patient had tabes dorsalis ("tabes fruste"). This observation scarcely bears out Sicard's views, and it must be admitted that the clinical conception of "ascending neuritis" rests upon a very doubtful pathological basis. Guillain [6] has classed the condition with tetanus and rabies, but Sicard rightly points out that these cannot be regarded as neuritic processes, but as examples of a specific conductivity of toxins and organisms along the nerves, unaccompanied by morbid change in the nervous elements. Recent research has fully confirmed the earlier observations on the passage of toxins and organisms along the perineural lymph channels, and Orr and Rows [15] have shown that commonly the conducting nerve shows no true neuritis; the nervous lesion first appearing in the posterior root entry zone when the sheath of Schwann has been shed by the entering fibre. Clinically also, there are no prominent symptoms of any affection of the conducting nerve, though there may be, as in the case of tetanus and probably that of diphtheria, symptoms referable to that segment of the central nervous system to which the conducting nerve is attached.

While, therefore, the pathological basis of the clinical syndrome of *la névrite ascendante* is doubtful, there is clinical evidence that probably it is not an example of the "lymphogenous toxi-infective" process described by Orr and Rows. In fact, obscurity pervades the whole subject on both clinical and pathological sides.

CLINICAL.

Certain cases which came under my observation during the course of military service correspond in their apparent cause and, in some respects, in their clinical picture to the syndrome of "ascending neuritis." As I have stated, it is probable that cases of this type may have helped to swell the ranks of Babinski's "reflex nervous disorders," though to a small extent. Therefore, an examination of them from the points of view discussed here may help to lend precision to our clinical notions of these conditions.

Case 1.—*Small suppurating wound of dorsum of foot followed by paralysis of all muscles supplied by external popliteal division of sciatic nerve, and corresponding sensory loss.*

Private J. was lightly wounded by a fragment of shrapnel on the dorsum of the left foot at the base of the fourth and fifth toes, in April, 1916. He walked unassisted to a dressing station one and a half miles away. Moderate local swelling developed, but the wound healed in two weeks. On beginning to walk more freely the scar broke down and for some days discharged freely. As soon as the second healing was complete and he began again to walk he found that the toes of this foot dragged and caught the ground as he walked uphill. This disability increased, so that now, three months later, he is unable to move foot or toes. He is conscious of an area of skin on the dorsum of the foot which "feels numb and asleep," but beyond an aching in the muscles after exertion he has at no time had any pain. In all other respects he is in normal health.

On examination (July 10, 1916): There is a small scar between fourth and fifth toes on the dorsum of the left foot. There is complete paralysis with marked wasting of the antero-external group of muscles of the leg. Foot-drop is complete and the foot hangs inverted. There is slight general wasting of the whole limb, but the localized wasting noted is distinct from this. The affected muscles are slightly tender to pressure; other muscles show no tenderness. The nerve as it turns round the fibula is tender to pressure, but is not thickened. On the dorsum of the foot and extending over the outer four toes is an area of subjective numbness and of slight objective blunting of sensibility to touch and pinprick. Deep sensibility is normal in the foot and digits. The ankle-jerk is brisk, and the other limb reflexes are all normal. No trophic or vasomotor changes are present.

No electrical examination of the muscles was possible at the time.

In this case a superficial wound within the cutaneous territory of the external popliteal division of the sciatic nerve produced a complete paralysis with wasting of a group of muscles supplied by that nerve. Muscles innervated by the internal popliteal division were unaffected and the ankle-jerk was normal. There appears nothing noteworthy about the injury, apart from the fact that it was the seat of a definite septic process.

Case 2.—*Superficial wound of lower third of thigh followed by paresis and wasting of quadriceps extensor femoris and diminution of knee-jerk.*

Private McD. was wounded in the left thigh in April, 1916. The wound healed in three weeks without untoward occurrence. About two weeks after return to duty he noticed pain down the front of the thigh on exertion, and a tendency of the knee to give way. This disability increased, so that he was evacuated overseas. On examination (July 24, 1916, that is, three and a half months later), two small healed wounds are seen on the anterior and antero-lateral aspects of the thigh, two and a half inches above the patella. No deep thickening can be felt along the superficial course of the track between these wounds, but this can be felt as a thinning of the subcutaneous fat. X-ray reveals no signs of deep bony injury. There is marked weakness, wasting and tenderness on pressure of the vasti and rectus femoris. The knee-jerk is very feeble, its fellow being brisk. Adductors, posterior thigh muscles and muscles below the knee are normal. The ankle-jerk is brisk. There are no sensory changes.

In this case a superficial wound, involving only skin and subcutaneous tissues, within the territory of the anterior crural nerve has resulted in an atrophic paresis of muscles supplied by this nerve, with gross diminution of the corresponding jerk.

Case 3.—Penetrating wound of the leg in its distal third. Drop-foot, and diminished faradic excitability of all muscles below the knee. No sensory loss. Diminished ankle-jerk. Cyanosis, coldness, and lesions resembling chilblains on foot.

Private B. received a bullet wound running antero-posteriorly through his left leg from behind forwards, between tibia and fibula at junction of middle and lower thirds. He has been unable to move toes or foot freely since. Beyond aching on exertion he has had no pain in the leg, nor any paræsthesiæ in the foot. When cold the foot becomes blue and "irritating spots" come out on the sole and inner part of the foot. During the five months that have elapsed since his wound there has been some wasting of the leg. Examination five months after injury: There are small entry and exit wounds as described. Under the larger anterior scar there is a small muscular hernia when the foot is passively dorsiflexed, otherwise there is no sign of gross injury to muscle, tendon or blood-vessels. The foot hangs dropped and inverted. It is cyanosed and along its inner border and round the heel are numerous small red raised areas resembling chilblains. The calf at its thickest part shows a wasting of one and a quarter inches. This loss of substance is general and not localized to any particular muscle group below the knee. There is some contracture in the calf, and the foot cannot be dorsiflexed passively to less than an angle of 100° with the leg. There is very feeble voluntary power of dorsiflexion of foot and toes within these limits. Plantar-flexion is of fair power, but not normal. The peronei are also very feeble. There is no mechanical excitability of the affected muscles, but slight tenderness on pressure and a slight but definite diminution of faradic excitability of all muscles. The ankle-jerk is very sluggish, its fellow being brisk. The plantar reflex is feeble. Both knee-jerks are brisk. Above the knee there is no abnormality. There is no sensory loss. The patient walks with leg rotated out and steppage gait. Final examination ten months after wound reveals practically no change since first coming under observation five months before.

In this case all muscles below the knee, especially the group supplied by the external popliteal division, show marked paresis with some wasting, although their nerve trunk cannot have been involved by the bullet in its track. There can be no question that the symptoms were either hysterical or simulated.

Case 4.—A blow on the heel, no wound. Severe and progressive atrophic flaccid palsy of all muscles supplied by the sciatic nerve, with corresponding change in reflexes, and sensory loss. Marked cyanosis and coldness of foot.

Private S., on November 6, 1917, as he was lying on his face during an advance, was struck on the iron heel-cap of his left foot by a spent bullet. At once the whole leg "went useless." But there was no severe pain. He was unable to stand and was carried off the field. He could move his toes feebly during the ensuing week as he lay in bed. Examined ten days after injury, there is no sign of external injury, no bruising or swelling. A skiagram shows "some superficial damage to the outer surface of the external malleolus, a small thin flake being detached—the attachment of the external lateral ligament." The left lower limb already shows a slight general wasting, amounting to a difference of one inch in the circumference of thigh and calf. As he lies in bed there are no vasomotor changes and no œdema. All muscles below the knee show complete loss of power and of faradic excitability. They are extremely tender to pressure, but show no increased mechanical excitability nor any fibrillation. The hamstrings are of normal power, but somewhat tender to pressure. Quadriceps extensor femoris and the adductors are normal in power and faradic excitability and are not tender. The ankle-jerk is absent the knee-jerk normal. There is no plantar response. There is constant pain referred to the inner half of the sole and in the arch of the foot, radiating thence into the calf when most severe. Objectively, there is sensory loss over the whole foot up to the level of the malleoli and over the lateral aspect of the leg, corresponding exactly with the cutaneous distribution of the sciatic nerve. Cotton-wool touch is markedly impaired over this area, and also sensibility to pain and temperature. There is diminution of vibration sense over foot and tibia and loss of position sense in the toes.

When allowed to hang down, the foot becomes blue and cold. The nerve trunk as it turns round the fibula is exquisitely tender to pressure but not thickened. The sciatic trunk is not tender.

On the twenty-second day of the illness, the hamstring muscles are tender to pressure, weaker than their fellows and show slight definite wasting. The hamstring jerk, normal on admission, is now appreciably diminished. The sciatic trunk up to the buttock is becoming very tender, and flexion of the extended leg on the hip is painful. Below the knee wasting increases and pain is almost constant, rendering the patient restless and sleepless. The calf is so tender that the weight of the limb is distressing when he lies on his back. The knee-jerk remains brisk, the knee extensors active and normal in every respect.

On the sixtieth day: The process is extending and increasing in severity, but is still confined to the sciatic nerve. The hamstring-jerk is just obtainable, and its muscle wasting rapidly. The muscles below the knee are showing progressive atrophy. Sensory changes are as before. Mechanical excitability of muscles shows no abnormality. The knee extensors and the knee-jerk remain normal.

Seen for the last time on the eighty-second day, the hamstring-jerk is absent, and no improvement of any kind is to be seen.

The case is noteworthy in that the septic factor can be excluded, and that no direct injury of the nerve endings occurred. The severe progressive paralysis resembled clinically a sciatic neuritis, spreading up the nerve.

CLINICAL SUMMARY.

We find that (1) a trivial injury, not necessarily a wound and not involving a nerve trunk, may produce marked paresis, or paralysis, with wasting of muscles and diminution of their faradic excitability, impairment of the corresponding tendon-jerk, subjective and objective sensory changes and vasomotor disturbances.

(2) These signs have a definite anatomical topography and correspond to the innervation of a peripheral nerve.

(3) The character of the symptoms is that of a localized neuritis (mono - neuritis). Though in every instance progressive, there is evidence of continued upward extension in only one (Case 4).

(4) In every instance the injury was within the territory innervated by the affected nerve, though not involving its trunk. In two cases (Cases 1 and 2) the cutaneous endings of the nerve had been directly injured. In one (Case 4) it overlaid these, while in one (Case 3) it involved both deep and cutaneous afferent endings.

(5) Sepsis—if we admit Case 4 to the group—does not appear to have been an essential factor.

It is clear that in these cases we are not dealing with a random paralysis, but with an organic disturbance of structures anatomically related. They approximate in type to the conditions known as "ascending neuritis," rather than to the muscular reflex affection of acute arthritis and allied lesions. It is probable that a small proportion of Babinski's cases of " reflex nervous disorders " may have been of the same nature.

In the absence of any sound pathology of these clinical conditions, it is not possible to dogmatize as to the lesion underlying the cases reported here. They indicate, however, that in rare instances the clinical manifestations of a local neuritis may follow trivial injuries, commonly associated with organismal infection, of the afferent terminations of the nerve affected.

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Section of Neurology of the Royal Society of Medicine.

President—Dr. W. ALDREN TURNER, C.B.

DEMONSTRATION OF CASES ILLUSTRATING THE LATE EFFECTS OF INJURIES OF THE NERVOUS SYSTEM[1]

Shell Wound of Head, Right Temporal Region, Sensory Paresis of Left Hand and Foot; Mental and Physical Symptoms due to Hole in Skull; Effect of Closure with Osteoplastic Graft.

By HENRY HEAD, M.D., F.R.S.

(1) CAPTAIN E. C. T. E., R.A.M.C., aged 29; wounded March 22, 1918, with the fragment of an aëroplane bomb. He did not realize he was hit, but continued to dress the wounded. Was wearing nothing on his head at the time. Then remembers nothing until he found himself in Rouen. He was admitted to the casualty clearing station with a "small penetrating wound through outer and inner tables of the skull and a small piece of the inner table had been driven into the brain. There was a large extra- and intra-dural hæmorrhage." He arrived at Rouen on March 26, and the wound was explored two days later. A subdural hæmorrhage was found and the wound was drained. He made an uninterrupted recovery.

Admitted to the London Hospital on April 13, 1918, with paresis of left arm, leg and face. The wound had healed except for some granulating tissue over the centre of the pulsating portion. It was situated in the right temporal region 15 cm. to 19 cm. behind the nasion and 7 cm. to 10 cm. to the right of the middle line; total nasion-inion line, 35 cm. At this time he suffered greatly from headache. The lower portion of the left half of the face was weak and the tongue was protruded somewhat to the left. All the deep reflexes on the left side were brisker than those on the right, but there was no ankle clonus and the plantar gave a downward response; the abdominal reflex was absent on the left side. Grasp of the left hand was weak and isolated movements of the fingers were poorly performed. The lower extremity was not affected. The greatest change was in the sensations from the left hand and foot. Recognition of passive movement was diminished in the whole of the left hand and great toe, but not in elbow, shoulder or ankle. The compasses were badly discriminated over index, middle, ring and little fingers and over the left sole. Localization was poor over the four fingers but good over the sole. The tactile hairs showed loss of sensibility of these fingers and the sole, but there was no definite loss to temperature, and prick was unaffected. There was gross loss of recognition of shape and texture in the left hand.

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[1] At a meeting of the Section, held December 11, 1919.

In May, 1919, he was admitted under my care, at the Empire Hospital, for headache. The wound was deeply depressed, pulsating, and he was perpetually conscious of the opening. Stooping upset him; he could not travel in the train or play golf. Concentration and intellectual effort at once brought on a headache. The physical condition was almost exactly as before.

On May 28, 1919, Mr. Wilfred Trotter filled in the hole in the skull with a piece of bone taken from the right shin. The wound healed by first intention.

The skull now felt completely normal on palpation, and it would have been difficult to say where it had been repaired. All signs of pulsation had disappeared, and the scar was absolutely painless. He was no longer troubled with the feeling of an opening in the skull, but could stoop and make unexpected movements without any abnormal sensation. His power of intellectual effort increased, and he was again able to play golf.

[This patient was unavoidably prevented from attending the meeting, and was replaced by the following officer.]

(2) Captain E. N. C., Indian Army, on February 19, 1918, was serving in Mesopotamia; his saddle slipped, and he fell under his horse. He was kicked in the left parieto-occipital region, and sustained a compound fracture of the skull. He was operated upon within a few hours. "Bone fragments were removed; the brain below the injury

was pulped to a depth of about 3 in., and hernia cerebri developed, which subsided after three lumbar punctures." He was admitted to the Empire Hospital for Officers on September 6, 1918. The wound had healed completely and was covered with a deeply depressed pulsating scar. He showed definite aphasia and right hemianopia, with loss of central vision on the blind side. There were no other abnormal physical signs. He suffered from no headache, but was much troubled with consciousness of the opening in his skull. He could not stoop or make any sudden movement without the pulsation increasing considerably. He was easily tired, both by travelling in the train and intellectual effort. Physical exertion, such as walking, did not produce abnormal fatigue.

On October 17, 1919, Mr. Wilfred Trotter filled in the hole in the skull with three grafts from the tibia. The opening measured 11 cm. in length, and 5½ cm. vertically. The wound healed by first intention, and when the patient was shown at the meeting it was impossible to make out with certainty where the opening had been.

The most striking change was the patient's recovery of confidence in himself; he no longer feared to stoop, or to make sudden movements, and lost the habit he had acquired of placing his hand over the opening when he sneezed or coughed. Associated with this recovery of self-confidence, his power of speech distinctly improved.

Closure of Openings in the Skull by Bone Grafts.

By WILFRED TROTTER, M.S.

OPERATION: The opening is exposed by the reflection of a large flap, not including the pericranium. If the scar of the original injury in the scalp is of doubtful vitality it should be excised and the opening in the flap stitched up. The gap in the skull is outlined by an incision down to the bone at its edge. The pericranium is reflected away from the opening. The dura and scar are freed from attachment to the bone, and the scar is pared down as much as is possible without opening the subdural space. No harm will result if the subdural space is accidentally opened. The rounded edge of the bone is cut away with a chisel so as to give a flat surface on which a graft can lie. Thin slices of adequate size to overlap the opening are then cut with a frame saw from the inner surface of the tibia, the periosteum being divided and reflected in such a way as to leave a fringe projecting all round the graft, but especially at its ends. The graft is laid on the opening and secured firmly in close apposition to the skull by numerous stitches between the fringe of periosteum surrounding the graft and the fringe of pericranium surrounding the hole. In this way absolute fixation can always be secured. Most openings left by war wounds can easily be closed by two grafts, but sometimes more are necessary. It is not difficult to reconstitute the skull—even though flat grafts alone are used—in such a way that after a lapse of some months it is scarcely possible to detect any abnormality in shape.

Indications for operation: It is rare for any patient who has an opening in the skull to be quite free from symptoms. The smaller the opening and the more rigid the scar by which it is occupied the less likely are the symptoms to be pronounced. The commonest symptom is tenderness of the scalp around the gap. When the latter is in a situation to be pressed on by a hat the inconvenience is serious. Consciousness, more or less unpleasant, of movement at the opening is also common. This of course varies with the area and the thinness of the scar. Every movement that causes even a slight variation in the venous pressure is felt at the opening. Thus when the patient stoops, coughs, sneezes, laughs, or makes any effort, he feels the brain bulge and the scar stretch. One patient, who had had an inguinal hernia, compared the feeling in the head when he coughed or laughed with that which the rupture had given him. Sometimes the arterial pulsations of the brain are a source of distress, especially in the recumbent posture. Actual headache comes next in the order of frequency. To be characteristic it should show evidence of a mechanical origin, being brought on either by the depressed or the expanded position of the brain. In the former case, the patient will say that he wakes in the morning without headache, but that this comes on after he has been on his legs some time, and is at its worst at bedtime. In the other case the patient will wake with headache, which improves after he has got up.

In certain cases of traumatic epilepsy there is evidence that the opening aids in maintaining the abnormal excitability of the brain. When the onset of the fits has a definite relation to posture, this possibility should especially be considered. Frequently it is obvious that the opening in the skull is a source of uneasiness and distress that the patient cannot put into definite words. He may complain of being worried by the unnaturalness of his condition, by a supposed danger of injury, or he may be able to do little more than convey a sense of anxiety, not the less distressing for being indefinable. Whether these are to be regarded as evidences of disturbed function of the brain or of the mind, they are invariably relieved by closure of the opening. Whenever headache is a pronounced symptom and the opening is small and the scar rigid, the possibility that there is an element of unresolved contusion in the case should always be considered. When there is little movement of the scar with changes in posture, the mere opening is unlikely to be a source of the symptoms. When there is any doubt as to the diagnosis, an exploratory operation to determine the condition of the brain should be done.

Shell Wound of Head, 1915; Persistent Headache Four Years; Operation; Free Opening of Skull and Dura in Region of Injury; Contusion of Brain Found; Relief of Headache.

By WILFRED TROTTER, M.S.

J. W., AGED 31. Shell wound of skull, 1915. Patient did not remember anything for several days after. He had two operations for removal of fragments of bone and metal. The wound healed in about ten weeks. As soon as he was allowed out of bed headache began and persisted up to the recent operation four years later.

Character of headache: A dull aching pain was continually present and was liable to severe exacerbations. These were brought on by exertion, fatigue, excitement, or worry. The headache when severe was accompanied by giddiness. On three occasions he "fainted" at his work. He was unable to continue his work as a gardener, as stooping was particularly apt to bring on the pain. The headache was felt over the vertex of the skull round about the scar.

Operation, November 11, 1919: Bone removed in region of the scar and dura incised freely. There was slight bulging of the brain. The arachnoid was opaque and slightly distended by fluid collected under it. The brain was stained an orange colour as the result of extravasation of blood. The conditions were typical of an old unresolved contusion. There has been a great improvement in the headaches since the operation.

This case is shown as characteristic of a common sequel of head injury due to war wounds. The pathological basis of the condition is an unresolved contusion of the brain substance; of its clinical manifestations, headache is by far the most conspicuous.

In a typical case the history will be that the patient has suffered a local injury to the vault of the head from a bullet or shell fragment. The injury may appear to have been a mere graze or to have involved the bone. It will be characteristic that there has been no great loss of bone substance. If there has been a perforation of the skull the opening will be quite small and usually closed by a rigid scar. The headache generally comes on, or is first seriously complained of, during convalescence, when the patient is beginning to get about. There may be more or less continuous moderate headache, but the chief feature is the liability to attacks of very great severity. Such attacks may last from a few hours to several days, and are apt to be brought on by physical exertion, by exposure to bright lights or loud noises and by mental excitement. In some cases stooping and even a brief physical effort may cause a throb of intense pain and, if often repeated, lead to a definite attack. During the attack the headache is of an intense throbbing, bursting character and often of unbearable severity. In many cases the patients declare that between attacks they feel perfectly well. Giddiness is often complained of and is brought on by the same causes as produce pain. If the injury is appropriately situated there may be signs of slight functional defect of the cortex, but commonly headache is the dominating symptom. When the brain in the region of the scar on the scalp is explored evidences of an old contusion are found. There may be more or less increase of tension, but this is so slight as often scarcely to be distinguishable from the effect of venous engorgement due to the anæsthetic; the arachnoid is opaque and its trabeculæ unduly visible, and it is distended by the local accumulation of fluid beneath it; the brain shows discoloration from old extravasation of blood. In the patient shown, the brain in the contused region was of a deep orange tint though four years had elapsed since the injury. The evidences of contusion vary in intensity, and in well marked cases amount to a definite meningitis serosa circumscripta. Occasionally a small amount of actual blood clot is found on the surface of the brain.

After free removal of bone and incision of the dura the headache is greatly relieved or completely cured. Some months later the opening in the skull should be closed.

On the theoretical aspects of the condition it may be desirable to call attention to two well established matters of principle. First, the resilience of the skull is such that it may be accepted as an invariable rule that whenever a missile travelling at high velocity touches the bone, the latter is driven in upon the brain with force enough to inflict a considerable bruise. It is quite unimportant whether the bone shows evidence of injury to ordinary clinical or X-ray examination. The bone may have recovered its shape completely and have sustained no fracture and yet have caused a distinct local lesion of the brain. If it can be shown, then, that such a projectile has touched the skull the existence of a local cerebral contusion at the point of contact may be assumed.

Secondly, the brain, being the only organ in the body with a capsule (the skull) completely rigid to all physiological forces, is unable to undergo the compensatory general swelling by which the circulation is maintained through any other bruised organ. Thus it is that a contusion of the brain is apt to remain unresolved much longer than a similar condition anywhere else. In the case shown, there were visible evidences of contusion no less than four years after the injury. This tendency of lesions that elsewhere would be trivial and passing to persist and cause grave symptoms is altogether peculiar to the brain. Like very many other phenomena special to cerebral pathology, it is a direct consequence of encapsulation by the skull.

Gunshot Wound of Head; Fracture of Left Frontal and Parietal Bones.

By OSWALD SHIELDS, Major R.A.M.C.

PENSIONER A. J. G., aged 21. Wounded on September 1, 1918 (bullet); bullet entered left parietal and passed out through left frontal region.

Operation in France on September 2, 1918: Entrance and exit wounds excised, and fragments of bone removed; extensive laceration of brain found.

Symptoms: Very severe frontal headaches.

Operation on November 22, 1918, by Major Shields: Plate of perforated celluloid placed over opening in skull in order to close gap (at this time the smooth celluloid plate was not being inserted between skull and dura). Headaches were much relieved for eight months, then again became severe.

Operation on October 28, 1919, by Colonel Sargent: Hole in skull enlarged and celluloid plate removed; dura freed from skull and thin sheet of smooth celluloid placed between skull and dura; perforated celluloid placed over opening in skull, and scalp sutured in place.

Gunshot Wound of Head; Fracture of Left Frontal and Parietal Bones.

By OSWALD SHIELDS, Major R.A.M.C.

PENSIONER S. H., aged 25. Wounded on April 27, 1915 (shell).

Operation (in France): Decompression; date uncertain.

Symptoms: Severe frontal headache, vertigo and fits, becoming more severe.

Operation on February 28, 1919, by Colonel Sargent: Dura found adherent to brain; fat graft inserted between dura and brain after freeing; double celluloid perforated plate placed over opening in skull; scalp sutured in place.

Operation on March 14, 1919, by Colonel Sargent: Celluloid plate removed and replaced by perforated zinc plate. Suppuration followed.

Operation on March 24, 1919, by Colonel Sargent: Zinc plate removed; fat graft seen to be necrosing in places; August 18, 1919: three fits; another on September 27, 1919.

Operation on November 18, 1919, by Colonel Sargent: Old fat graft found to be completely fibrous and adherent to pia, so that it could not be removed; it was freed from skull around opening; a thin smooth celluloid plate was inserted between skull and fat graft, and a large thick perforated celluloid plate made to the shape of the skull was placed outside skull to cover the opening; scalp sutured in place.

Facial Paralysis.

By E. FARQUHAR BUZZARD, M.D.

PENSIONER B., aged 23. Blown up by shell on April 1, 1918; face swelled up and paralysis was noticed two days later; weakness in left arm and leg was present at first, has since improved, but still shows on much exertion; there is now complete facial paralysis and loss to faradism, except for orbicularis oris. Probably there is a pontine lesion in region of right facial nucleus, orbicularis oris fibres escaping.

Case of Spastic Paraplegia illustrating certain Reflex Phenomena and the Impeding Influence of Muscular Hypertonicity and Reflex Spasms on Voluntary Movements of the Lower Limbs.

By GEORGE RIDDOCH, M.D.

SECOND-LIEUTENANT F. C. J., late L.N. Lancs, was shot by a sniper in the back on July 31, 1917. He sank to the ground at once and was unable to move his legs. Free from pain at first, he suffered later from intense soreness of the inner aspects of the arms from the wrists to the axillæ and of the upper part of the back and chest while being carried to the aid-post on an improvised stretcher.

On admission to the Empire Hospital on August 3, 1917, his condition was found to be as follows: The bullet had entered in the left supraclavicular fossa, crossed the back and made its exit 10 cm. to the right of the second thoracic spine. The pupils were equal and reacted well to light and shade. Reflexes: Arm-jerks were present and equal on the two sides; abdominals absent in all segments; knee- and ankle-jerks not obtained. On scratching either sole with a pin a feeble flexion reflex with up-going toes was evoked. Motion: Complete flaccid paralysis of the lower limbs and trunk below the fourth rib. No involuntary movements of the lower limbs were present. Sensation: On the chest, back and inner aspects of arms and hands in the distribution of the eighth cervical, and first, second and third thoracic posterior roots, a dragged pin gave rise to a disagreeable feeling of soreness. Below the fourth rib, though there was complete loss of sensibility to prick, light touches were appreciated, and better on the right than on the left half of the body. Bladder and rectum: Retention of urine and fæces.

X-ray examination: No displacement nor fracture of bone could be seen.

Operation: Forty-one days after the injury the spines and laminæ of the seventh cervical, and first, second, and third thoracic vertebræ were removed. Unfortunately, a record of the condition of the membranes and cord found at operation does not seem to have been made.

A fortnight after the operation the patient could move the toes of his right foot and slightly bend the right knee. Some weeks later similar movements were possible in the left lower limb. At this time all involuntary movements were flexor in type, and it was not till March, 1918 (eight months after the injury), that strong extensor spasms appeared. About a month later he was able to initiate extensor movements of the legs by voluntary effort. It was now possible to begin stepping exercises. Though voluntary power was slight it was sufficient to change the direction of the reflex movement from extension to flexion or flexion to extension. So the sequence of events was as follows: When placed on his feet, the tension on the calf-muscles excited strong extension of both legs and he was able to stand upright, balancing himself with the help of the self-propelling chair. Then concentrating his attention on one leg he could inhibit the tonic limb extension and evoke a flexor spasm, this in turn being replaced by extension. The process was next repeated in the opposite limb. Because of the spasticity the effort expended was very great and the exercise could be gone on with for a short time only. Gradually, however, he regained more control over the limbs.

His present state, two years and four months after the injury, can be summarized as follows:—

Reflexes: Abdominals.—When the stimulus is applied in the epigastric region a local reflex response is obtained, but when the site of stimulation is near the groin a general contraction of the muscles of one half or of the whole abdominal wall usually results. Cremasteric and bulbo-cavernosus reflexes are present and erection of the penis is of frequent occurrence. Knee- and ankle-jerks are very brisk on both sides, and foot and patellar clonus is well sustained. The twitch of the knee-jerk is often followed by rhythmic extension of the limb at hip and knee due to contractions of the glutei and quadriceps extensor cruris muscles occurring at the rate of about four in five seconds. These movements, which are most often bilateral, move the pelvis forwards and backwards. The hamstring muscles take part in the backward movement. This reaction often follows a bilateral extensor spasm and is evoked by handling the penis or by rubbing the lower part of the abdomen or the inner surface of the thighs. It is inhibited by nocuous stimulation of the sole of the foot or by dorsiflexing the foot suddenly; the former mode of stimulation exciting a flexion reflex and the latter an extensor thrust.

Flexion reflex: Flexion of the lower limb with up-going toes is obtained by pinching, pricking or scratching the foot or the leg. Evoked by squeezing the upper part of the thigh it appears sometimes to be a primary reaction, but most often it is secondary to a brief downward movement of the toes. The lower limbs are so sensitive to stimulation and the reflex movements evoked are so vigorous that it is difficult to determine the exact nature of the crossed response with the flexion reflex. The obvious movement is flexion, but sometimes initial—very brief—extension is apparent. After a flexor spasm the lower limbs usually extend vigorously at hip, knee, and ankle, all the muscles of the thigh and leg being strongly contracted. The toes, however, are dorsiflexed. An extensor thrust of the limb, in which the toes move down, is obtained by pressing on the sole of the foot so that the tension on the calf muscles is increased. Abduction and eversion of the foot tend to be associated with extension of the limb and adduction and inversion with flexion.

Motion: He can perform all movements of the trunk and lower limbs, but in attempting to flex or extend the legs he has still great difficulty in controlling spasms. He can determine the direction of the movement, voluntary impulses exciting the appropriate motor paths. But once started the movement is carried on largely by reflex action outside his control, and he has great difficulty in regulating its amplitude and vigour. In addition the hypertonic condition of the muscles offers great resistance to voluntary effort. He moves his limbs more freely and in a more controlled fashion after they have been immersed for a time in a hot bath. Independent movements of the foot and toes are possible, but when asked to flex or extend the knee or hip all the flexors or extensors of the limb are brought into action. Involuntary flexor and extensor spasms of violent character are still frequent Both flexor and extensor muscle-groups are hypertonic, but when the limbs are moved passively the resistance encountered in the extensors is different from that in the flexors. The resistance of the extensors is maximal at the beginning and then suddenly gives way, while that of the flexors is more or less constant throughout, the muscles gradually lengthening. There is very little muscular wasting.

Sensation: The inner aspects of the arms and the upper part of the chest and back are much less tender to touch and pressure. Below the level of the fourth rib light touch is everywhere appreciated, though less clearly than in normal parts. The defect increases towards the feet. Pin-pricks are said to be "sharper" and "more disagreeable" than normal, and cold objects give rise to a sensation with a distinctly painful quality. The vibrations of a large tuning fork (C_{128}) are not appreciated in the lower limbs and trunk below the sixth rib, and the recognition of changes in posture and of passive movement is gravely disturbed.

Vaso-motor, secretory and trophic changes: Dependence of the limbs does not cause œdema, and the patient never sweats from the trunk and legs. The skin is dry and scaly. There are no bed-sores.

Bladder and rectum: He is able to control to some extent the automatic activities of the bladder and rectum. Micturition can be started off before the bladder is full, and provided the contents of the rectum are soft he can expel them by voluntary effort; he can prevent reflex micturition but for a short time only. He always knows when the bladder is full and when empty.

Case of Meningitis Circumscripta Serosa following a Bullet Wound of the Neck, with Injury of the Posterior Columns of the Spinal Cord.

By GEORGE RIDDOCH, M.D.

THE clinical features of this case due to the medullary injury were described in a paper read before the Section on January 24, 1918. It will be sufficient here to summarize them briefly.

Lieutenant B., R.A.F., was struck by a bullet in the back of the neck on August 12, 1917, while flying. Both arms were immediately paralysed, but he could move his trunk and legs fairly well. He suffered from intense pain across the shoulders, which were very tender to touch. Injury to the third cervical laminal arch was noted at the casualty clearing station, and an unsuccessful attempt was made to remove pieces of metal which were lying in the soft tissues of the back of the neck.

On admission to the Empire Hospital on October 20, 1917, the wound had healed, but in the track of the scar there was an oval depression, 6 cm. long and 3 cm. broad, the floor of which appeared to rest on the laminal arch. X-ray examination showed that damage had been done to the spines and transverse processes of the third, fourth, fifth, and sixth cervical vertebræ. The left pupil was larger than the right and there was slight ptosis on the left side. Poorly sustained ankle clonus was obtained and on scratching the sole of either foot hamstring contraction accompanied downward movement of the hallux. Other reflexes were normal. Except for weakness of both arms, especially of the hands and fingers, and on the right side more than on the left, motor power was very little affected. There was slight wasting of the arms but more of the fingers, and the tone of the muscles was greatly diminished. The movements of the arms, especially of the hands and fingers, were grossly inco-ordinate. His gait was ataxic, and when he stood upright with his eyes closed he swayed from side to side. Tactile sensibility was gravely disturbed in the pre-axial side of the forearm and in the thumb and first three fingers. Over the same area sensibility to prick, heat and cold was defective. Tactile localization and the appreciation of deep pressure and pressure pain were everywhere unaffected except in the hands and forearms. The spacial elements were disturbed in the hands and arms out of all proportion to the other aspects of sensation. He was quite unable to find objects with his hands in the dark or when his eyes were shut, though he knew their position in space quite well. To turn on the bed-lamp in the night he had to grope for the switch with his upper arm and then press it down with his teeth. He was quite unable to dress himself and had to be fed.

Though the sensory condition of the hands has not altered much in the last two years, and the movements of his hands are clumsy, he can now do everything for himself, and drives a motor car with safety even in the dark. He rode on a bicycle for a time but had to give it up as accidents were too frequent. So long as he kept a watch on his hands everything went well, but as soon as his attention was diverted by obstacles on the road his hands left the handle-bars and he found himself in the ditch.

In March, 1919, he was readmitted to hospital and Mr. Trotter obliterated the hole in his neck by a plastic operation. His general health at this time was excellent, but for the last three months he has been gradually becoming less fit. His gait is again unsteady at times and he has greater difficulty in controlling the movements of his arms and hands. The physiological deterioration dates from a bathing accident in August. While swimming under water on his back his head struck a ridge of sand with such force that he turned a somersault: he felt something click in his neck, was giddy and felt nauseated for a few minutes, but was able to get out of the water without help. A few days after the accident he noticed that the depression in the neck had reappeared.

In September he went to bed one night feeling out of sorts, and about four o'clock in the morning woke up sick and giddy. He vomited and felt very faint and dazed. Severe pain radiated from the region of the depression in the neck, over the back of the head, and spasmodically down the spine. He was compelled by the pain to keep his head, neck and shoulders rigid. His mother, who was with him, noticed that the hole had disappeared. The attack, after lasting for about six hours, stopped suddenly and he felt quite well again. Since then he has had five similar attacks, four in bed in the early morning and one while he was lying in his bath

On examination it was found that the skin corresponding to the distribution of all the cervical and the upper four or five dorsal nerves is very tender to pressure and to a dragged pin. The increased sensitiveness is most pronounced on the back of the head, the posterior part of the vertex; the sides of the head including the ears, the neck and over the shoulders and upper arms and the upper part of the chest and back.

In the attacks, which are precipitated by local circulatory changes connected with the supine posture, not only the cervical cord but also the medulla are implicated. Consequently decompression is a matter of urgency.

Subsequent report: On December 20 Mr. Trotter removed the laminal arches of the second, third, fourth and fifth cervical vertebræ. The exposed dura bulged through the opening and when pricked a stream of clear cerebro-spinal fluid spouted up to a height of 5 or 6 in. On slitting open the dura the arachnoid over the whole uncovered area was seen to be opaque and its strands thickened. The spinal cord, which pulsated fully, appeared to be normal. Having approximated the edges of the dura by two or three widely separated interrupted sutures, the muscles were firmly stitched together in layers and the wound closed. The patient stood the operation well and at the time of writing, seven days later, he is very fit, complains of no discomfort, and the tenderness in the cervical root distribution has gone.

Case of Lesion of the Suprascapular Nerve and First Dorsal Root, with Hemisection of the Cord produced by a Single Missile.

By C. P. SYMONDS, M.D.

E. R., AGED 28, while himself in the act of firing his rifle, was sniped at a distance of thirty yards: he fell back into the trench and at once noticed that his left arm was useless; he then found he could not sit up nor use his legs. On his way down to the clearing station he lost the use of his right arm and at the same time his power of speech, hearing and vision. He had retention of urine for a week, having to be catheterized. At the end of this time he recovered speech, sight and hearing, but remained quadriplegic. At the end of three months he recovered the use of his right arm somewhat suddenly. Power in the right leg returned slowly and it was eight months before he could walk. He continued to improve for another six months, and since then his condition has remained stationary. He now complains of weakness of the left arm and leg, and has noticed in his bath that he is unable to appreciate differences of temperature with the right leg.

On examination, there is the scar of a bullet wound on the outer aspect of the left arm 3 in. above the elbow: no exit wound. He shows slight narrowing of the left palpebral fissure, and the left pupil is constantly smaller than the right. There is complete atrophic palsy of supra- and infra-spinati on the left side; the intrinsic muscles of the left hand are completely wasted, resulting in *main en griffe*, and there is a band of cutaneous anæsthesia corresponding to the segmental distribution of the first dorsal root. Below this level, over the right half of the body and right lower limb there is impaired sensation to pin-prick and heat and cold, and some light touches are missed. The power and reflexes of the right lower limb are normal. The left lower limb shows spasticity in extension with exaggerated tendon reflexes, ankle clonus and extensor plantar response: the abdominal and cremasteric reflexes on this side are absent. Vibration sense is definitely impaired over the left tibia, and there is some loss of sense of position in the left foot.

Stereoscopic X-ray plates show the casing of a rifle bullet lying superficially to the left of the fifth cervical spine; in addition very numerous small metallic fragments representing the burst core of the bullet; these fragments are all superficial except a tiny one which is apparently within the vertebral canal at the level of the sixth cervical vertebra, the arch of which is fractured. The upper border of the scapula in the neighbourhood of the supra-scapular notch shows evidence of injury. Thus a single missile has divided the supra-scapular nerve, cut the first dorsal root close enough to its origin from the cord to implicate the cervical sympathetic fibres, and finally produced a hemisection of the cord itself.

Case of Spastic Quadriplegia following Injury of the Spinal Cord in the Upper Cervical Region, showing Certain Unusual Reflex Phenomena.

By E. FARQUHAR BUZZARD, M.D., and GEORGE RIDDOCH, M.D.

SERGEANT V., aged 35, wounded by a spent bullet in the upper part of the neck on February 7, 1915. Entry wound: Small round scar 1½ in. above and 1 in. behind tip of left mastoid. No exit wound. Patient says the bullet was found in his coat collar. Immediate paralysis and loss of sensation in trunk and all four limbs. For some time after being hit he was unable to speak and his breathing was much embarrassed. He was compelled to take quick short breaths. There was retention of urine at first, but in a few hours the bladder began to empty its contents automatically.

In a little over a week he was able to move his right great toe voluntarily, and three or four weeks later his left great toe. Voluntary power in his lower limbs improved steadily. About two months after he was wounded he could flex and extend the right thumb at the metacarpo-phalangeal joint. Sensibility in the trunk and limbs also began to recover and he regained some control over the bladder and rectum.

SUMMARY OF PRESENT STATE.

He has become, perhaps, too resigned to his disability.

Pupils: Right larger than left. Both are regular, central, and react well to light and on accommodation. Both dilate on shading, but the left sluggishly and with small excursion. Left palpebral fissure is narrower than right. Otherwise cranial nerves are normal.

Motion: He can perform all movements voluntarily. The legs are better than the arms and the right arm and leg better than the left arm and leg. Voluntary effort is handicapped by the muscular hypertonus. Of arm movements, adduction is performed better than abduction at shoulder and he finds it easier to move the arm backwards than to bring it forwards; at the elbow, extension is better than flexion, and pronation of the forearm than supination; at the wrist, extension is a little stronger than flexion. The fingers are used clumsily. On attempting to extend the fingers the hand remains somewhat flexed at the wrist, though less so than when the arm is lying at rest. When he makes a fist the hand is strongly extended at the wrist. He can oppose the thumb to the little finger but, like all other movements, opposition is performed slowly and deliberately. Muscular relaxation, on command, is delayed. On asking him to clench the hand and then to open it quickly, a quite appreciable interval elapses before the command is begun to be carried out and the movements are performed slowly and in a jerky fashion. When the patient flexes or extends either leg against resistance, the arms flex involuntarily at the elbow, extend at the wrist, and the fingers and thumb fan out; being extended at the metacarpo-phalangeal joints and slightly flexed at the interphalangeal joints (claw-hand). He can now walk for a short distance without support, though he has considerable difficulty in keeping his balance on account of the general extensor rigidity. He has to watch his feet carefully.

Posture: As he lies in bed the arms are adducted at the shoulders, almost completely extended at the elbows, slightly flexed at the wrists, the hands not being quite in line with the forearm, which is fully pronated; the fingers are extended, the thumb adducted and opposed to the palmar surface of the index finger, and the fifth finger a little abducted from the fourth. The lower limbs lie on the bed extended at hips and knees and rotated out; the feet point and the toes are somewhat adducted and in line with the feet. The right arm and leg are less rigid in their posture than are the left arm and leg. The patient, as a rule, sleeps lying almost supine, his shoulders flat on the bed, with his head rotated to one side, the arms extended along the trunk, the right hip slightly elevated, and the legs flexed at hip and knee, the left leg lying under and just behind the right. When he stands up, with his body bent forwards, his arms hanging straight and stiff and a little in front of his trunk, his neck flexed and rigid, he is the picture of helplessness and immobility.

Tone: All the muscles of the trunk and four limbs are hypertonic except those of the ulnar fingers. Tonus preponderates in the extensor muscle groups, hence the prevailing posture of the trunk and limbs. Resistance to passive movement is greatest when the arms are being abducted or rotated at the shoulder, flexed at the elbow, the forearms supinated, the wrists extended, and the thumb abducted. The ulnar fingers are comparatively mobile. In the lower limbs the adductors of the thighs are more tonic than the abductors, and the extensors of the thighs, legs and feet than the flexors. Hypertonicity is greatest in the muscles controlling the large joints, and is least in the small muscles of the fingers. If the arm is passively flexed at the elbow with quick jerks the resistance encountered is quick and sudden, as if the triceps had taken up a new posture for each varying length. This "lengthening reaction" can be evoked over a wide range of different lengths of the muscle. It is obtained with all the muscles of the arm and thumb, but is most evident in the adductors of the shoulder, the extensors (triceps) of the elbow, the pronators of the forearm, the flexors of the wrist, and the adductors of the thumb. The extensors of the trunk and lower limbs show the reaction less clearly.

Involuntary movements: An emotional disturbance such as a fright may cause the arms to jerk forwards, but the most interesting involuntary movement in the arms is the following: It is a sudden and violent spasm in which there is adduction and internal rotation at the shoulder, extension at the elbow, extreme pronation of the forearm, slight flexion at the wrist, and hyperextension and adduction of the fingers, the index passing below the middle finger and the little finger below the ring finger. The thumb is adducted and opposed, the terminal phalanx remaining hyperextended. The hand and fingers form a cone and the palm looks backwards and outwards. It may be brought on by a fright or by a tickling feeling in the nose. Flexor and extensor spasms of the lower limbs still occur, but they are less frequent than formerly.

Reflexes: All the tendon reflexes are much increased. Flexion of the lower limb with upgoing toes is evoked by scratching the sole of the foot. With it the opposite lower limb extends. The extension-rotation reaction in the arm can be easily excited by scratching the palm of the hand, the inner aspect of the arm or the front of the chest, between the second and sixth ribs. The threshold of stimulus is lowest in the palm and on the chest between the third and fourth ribs. The complete response is as follows: The stimulated arm is suddenly and vigorously thrust backwards. It is extended, adducted and rotated inwards at the shoulder, extended at the elbow, completely pronated, flexed at the wrist, the fingers being extended and in such a position that they form a cone with the middle finger in front and the thumb in the palm. The palm of the hand looks backwards and outwards. At the same time the trunk is rotated towards the stimulated arm, the opposite arm is adducted and rotated *outwards* at the shoulder, and slightly flexed at the elbow, while both lower limbs are extended, the ipsilateral more than the contralateral limb. The new posture is maintained for some seconds, though the exciting stimulus is brief, and then the body and limbs slowly assume their position of rest.

Sensation: All aspects of sensation are affected in the arms, trunk and lower limbs. Recognition of changes in posture, and of size, shape and form are grossly defective, especially in the hands and feet.

Bladder and rectum: He has almost complete control over the functions of the bladder. He still requires to take laxatives every day.

An Unusual Case of Complete Bilateral Spastic Paralysis of Face, Jaw, Tongue and Larynx, following an Acute Illness.

By JAMES COLLIER, M.D.

W. B., A GIRL, aged 10, was in every way healthy and normal until 6 years of age, when she is said to have contracted scarlet fever. Three weeks later, when convalescent from the scarlet fever, she is said to have acquired meningitis, the symptoms of which consisted in her developing a squint and becoming unconscious, and lying semiconscious for three weeks. Her limbs were not paralysed during this time. She has never been able to speak nor to move her face voluntarily, nor to eat nor swallow naturally since regaining consciousness. She is a very intelligent child and she writes well. With the exception that there is slight perversity of movement in the use of the fingers (she constantly uses the middle finger of both hands instead of the index finger for acts involving approximation with the thumb), the condition of the limbs and trunk are in every way normal. The ocular movements are normal, and are performed at command. With the exception of retraction of the angles of the mouth, there is no volitional movement of the face, jaw, tongue or larynx. The face is in spasm, as shown by the frowning expression and the retraction of the angles of the mouth.

The teeth are tightly clenched, with occasionally a little audible grinding, and the masseters are in spasm. There is much dribbling of saliva, which she circumvents with her handkerchief, so as to keep herself quite clean. She feeds by pressing soft food into her cheek with her finger, closing the oral aperture with the hand and squeezing it through the teeth by the pressure of her fingers upon the cheek. The reflex movement of the eyelids is normal. Reflex swallowing is normal. The emotional movements of the face in smiling and crying are normal, and during these movements only is the mouth opened, and it is then opened widely. The associated movements of the face on effort are normal. She makes no attempt at articulation. She has recently begun to use a slight laryngeal grunt as a query and as an affirmative.